DB61

SMALL SCALE
FINAL REPORT

HEAT PUMPS

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada
New Brunswick Energy Secretariat

Final Report

Province of New Brunswick

Energy Secretariat

WATER SOURCE HEAT PUMP MONITORING PROJECT

June 21st, 1985

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SMALL SCALE CREDA PROJECTS

WATER SOURCE HEAT PUMP MONITORING PROJECT

June, 1985

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The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

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This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

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Water Source Heat Pump Monitoring Project

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Federal/Provincial Conservation and Renewable Energy Agreement
Water Source Heat Pump Monitoring Program

1.0 Executive Summary

Work was performed by Adsett & Associates Ltd. of Keswick, N.B. concerning the creation and performance of a monitoring program for 12 water source heat pumps located within New Brunswick, Canada. The project was requested and funded under the Federal/Provincial Conservation and Renewable Energy Demonstration Agreement, (CREDA). The objective of the work was to determine the economic and technical feasibility of such systems in New Brunswick.

The main difference in the systems was the use of various heat sources. They included ground water wells, a pond, the ocean, a swimming pool and a river.

The heat pump systems consisted of a heat source, as stated, a circulating pump, and a heat pump unit. The circulating pump transfers the heat source liquid from its supply through the heat pump unit and discharges it. The temperature of the liquid is thus lowered and the heat transferred to the space heating air distribution system.

The monitoring systems consisted of electric consumption meters, temperature sensors, flow meters and heat meters. The electric consumption of the individual components and the heat transfer from the heat source to the heat pump and from the heat pump to the domestic water, (where applicable), were measured.

Some of the monitoring systems required manual meter reading while three systems used automatic data gathering. The automatic data gathering system was developed in Fredericton, N.B. and tested as a part of this program. Computer programs were created as necessary in order to disseminate the information.

The seasonal Performance Factor ranged from 1.06 to 2.47 while the seasonal heat pump Coefficient of Performance ranged from 2.11 to 3.00. System installation cost varied from $5,916 to $49,115, (3 units), and incremental payback was between 0.9 and 21.6 years. Tables # 2 & # 3 show these results. The major factors effecting energy savings appeared to be due to inlet source temperature and circulating pump energy consumption.

1.0 SOMMAIRE RECOMMANDATION

Le travail, qui consistait à créer et réaliser un programme de contrôle pour 12 pompes à chaleur eau-air situées au Nouveau-Brunswick, Canada, a été effectué par Adsett & Associates Ltd. de Keswick. Ce projet a été exécuté et financé en vertu de l'Accord fédéral-provincial de démonstration des économies d'énergie et des énergies renouvelables (A.D.E.E.E.R.). Le but était de déterminer la faisabilité économique et technique de ce genre de systèmes au Nouveau-Brunswick.

La principale différence entre les divers systèmes était la forme des sources de chaleur utilisées, soit des puits d'eau souterraine, un étang, l'océan, une piscine et une rivière.

Les systèmes comportaient une source de chaleur, comme on vient de le mentionner, une pompe de circulation et une pompe à chaleur. La pompe de circulation fait passer le liquide provenant de la source de chaleur à travers la pompe à chaleur et le rejette à la fin du processus. La température du liquide est ainsi abaissée et la chaleur est transférée au système de distribution d'air servant à réchauffer les locaux.

Les systèmes de contrôle consistent en un ensemble de watt-heuremètres, de détecteurs de température, de compteurs de débit et de calorimètres. La consommation électrique des diverses composantes et la quantité de chaleur transférée de la source de chaleur à la pompe et de la pompe à chaleur à l'eau domestique, le cas échéant, étaient ainsi mesurées.

Quelques-uns des systèmes de contrôle exigeaient une lecture manuelle des compteurs, tandis que trois d'entre eux faisaient appel à des dispositifs électroniques d'enregistrement des données. Ces dispositifs ont été perfectionnés à Fredericton (N.-B.) et testés dans le cadre du programme. Des programmes informatiques ont également été élaborés de façon à permettre la diffusion de l'information recueillie.

Le facteur de rendement saisonnier variait de 1,06 à 2,47, tandis que le coefficient de rendement saisonnier des pompes à chaleur se situait entre 2,11 et 3,00. Les coûts des installations se situaient entre 5 916 $ et 49 115 $ (3 unités) et le recouvrement différentiel était de 0,9 à 21,6 ans. Les tableaux 2 et 3 font état de ces résultats. Les principaux facteurs d'économie de l'énergie semblaient reliés à la température de la source d'approvisionnement et à la consommation d'énergie de la pompe de circulation.

2.0 Introduction and Background

Under a contract with the New Brunswick Energy Secretariat Adsett & Associates Ltd. initiated and carried out a performance monitoring program concerning 12 water source heat pumps located in the Province of New Brunswick. The objective of the work was to assist in the determination of the technical and economical feasibility of such systems in New Brunswick. This report describes the various heat pump systems, indicates energy used and determined to be saved, shows the applicable costs and describes problems encountered. Recommendations are given concerning the implementation and use of such systems.

Section 3.0 "Description of Systems Monitored" indicates the operation of each of the systems. Various heat sources are used ranging from the almost conventional well water source to a pond, swimming pool and rivers.

Section 4.0 "Monitoring Systems Description" outlines the basis of the monitoring procedures. Both manual and automatic data gathering systems were used. Not only was this project a test of water source heat pump performance but it assisted in the development and evaluation of a automatic data gathering system designed and produced in New Brunswick. The operation of this system is described.

Section 5.0 "Observations Concerning Monitoring Systems" indicates the problems and successes encountered in installing and operating the monitoring.

Section 6.0 "Performance Summary" indicates total energy usage from the heat pump system as well as "paid for", (electrical), energy usage. Other pertinent data given includes system Performance Factors and the heat pump Coefficients of Performance. Several of the heat pumps supplied domestic water heating assistance as well as space heating. Performance values concerning DHW heating assistance are shown and compared for two of the systems.

Section 7.0 "Cost Benefit Analysis" indicates the system installed costs, the cost savings attributable to the system and the predicted payback period.

Section 8.0 "Discussion of Results" concentrates on items which could make significant difference in overall energy savings. Components which required relatively high energy consumption are discussed. The effect of inlet water temperature on the unit's Coefficient of Performance is mentioned.

Section 9 "Conclusions and Recommendations" indicates seasonal values, as well as economic and technical feasibility. Recommendations concerning the viability of various water source heat pumps with different site conditions are given.

The Appendices give backup information and data concerning this project. This includes system and monitoring flow diagrams, individual energy consumption graphs, the equations used in calculations and the computer data.

3.0 Descriptions of Systems Monitored

Table #1 - "General Descriptions" lists each of the proponents and gives general particulars. All heat pump units are relatively similar with the exception that some can supply domestic water heating assistance and others cannot. The main difference in all the systems has to do with the type of heat source. As seen from the table, the heat source can be from a water well, a pond, a river, a swimming pool or the ocean. Figures are included in Appendix C.0 - "Heat Pump System and Monitoring Flow Diagrams" illustrating each of the proponent's systems.

By referring to the Typical Heat Pump System Schematic in Figure #1 the basic components and their interrelation with each other are seen. The basic components are the refrigerant/air condenser used for space heating, the water/glycol to refrigerant evaporator used for total source heat transfer and the compressor. An additional component used in certain heat pumps is a refrigerant to water condenser for domestic water heating assistance.

Water or glycol/water solution is transferred from the supply pump to the refrigerant to water evaporator before being discharged. Upon a call for space heating the pump, blower and compressor are activated and the water shut-off valve is opened. Heat is transferred from the source liquid to the circulating air used for space heating purposes. If domestic water heating assistance is performed heat is transferred as well from the source liquid to the domestic hot water. Domestic water is circulated by means of a hot water circulator located within the heat pump which is activated at the same time as the heat pump.

If the same water supply pump is used as is required for the general building domestic water supply, an expansion tank is installed downstream to the pump and it is activated and deactivated on low and high pressure settings instead of by the heat pump circuits.

Table #A1 - System Characteristics indicates the average inlet and outlet heat source and air supply temperatures as well as the approximate heat source flow.

The following briefly describes the particulars of each system. Diagrams concerning each are in Appendix C and can be followed when reading the applicable descriptions.

1) Deschenes Drilling. This system uses well water supply as the heat source. There is no domestic water heating assistance.

2) N. Douglas System. This system uses two heat pumps to meet space heating demand. Both units are of the same size having nominal capacities of 15.2 KW. The heat source is water from a pond located within the property. In evaluating this system each unit is monitored separately. One of the heat pumps supplies heating to the domestic hot water system. This was not monitored.

3) M. Flewelling. The Flewelling residence is located beside the Saint John River near Saint John, N.B. Three hundred meters of 38 mm PVC pipe has been placed in the Saint John River and connected to the heat pump unit. The lines are filled with a 50/50 solution of ethylene/glycol water. A circulating pump within the loop causes flow. The heat pump is designed to assist in domestic water heating.

4) R. Gallant. Water is supplied from a well for source heat transfer. The heat pump assists in domestic water heating.

5) H. Hooper. The same well is used for water supply and discharge. Water is supplied at 30 M below grade and discharged after passing through the heat pump at 120 M below grade. Domestic water heating assistance is given by the heat pump. This house does not use any auxiliary space heating.

6) Little Rock Fisheries. The system at Little Rock Fisheries is an attempt to evaluate the use of water source heat pumps within fishing boats for unattended space heating. It is now located in a fish-holding car in the Seal Cove Harbour located in Grand Manan, N.B. Ocean (salt) water is supplied to the heat pump and then discharged back to the ocean. Because of the corrosivity of the ocean water all materials including that of the unit evaporator must be resistant to calvanic corrosion. The evaporator was ordered separately and is made of cupro-nickel.

7) M. Schofield. The heat source for the Schofield system is an indoor swimming pool. The intent of this system is two-fold; first, to transfer excess solar heat from the swimming pool to space heating and second, to transfer air-conditioning heat from the house interior to the swimming pool in the summer. Passive solar is utilized in the swimming pool area. The domestic water supply is passed through piping underneath the swimming pool before entering the domestic hot water tank. The intent is to transfer heat from the swimming pool to domestic water for heating assistance. An electrically energized pool heater is used to increase the temperature of the swimming pool water as required. The pool heater therefore, indirectly transfers heat to the space heating system.

8) Tidehead Municipal Building. This system consists of three separate heat pumps connected to one supply and discharge well. One water supply pump is used.

9) K. Weisseneder. Water supply is by means of a well. The unit has the capability of providing domestic water heating assistance.

TABLE ONE - GENERAL DESCRIPTIONS

Proponent	Location	Type of System	Heat Pump Model	Building Type	Floor Area (M2)
Deschenes Drilling	Saint Quentin, N.B.	Water Well Source	Permatemp TP 80	- Two Story House	353
Douglas, N.	Hillsborough, N.B.	(2 Units Used) Pond Water Source Pond Water Source + DHW Assistance	Aquatec 52Hu	- Two Story House	372
Flewelling, M.	Saint John ,N.B.	River Water Source + DHW Assistance	Glencar 40	- Two Story House	188
Gallant, R.	Fox Creek, N.B. (near Moncton)	Water Well Source + DHW Assistance	Glencar GC-036	- Two Story House	140
Hooper, H.	Back Bay, N.B.	Single Water Well Source & Return	Aquatec 52Hu	- Single Story Bungalow	89
Little Rock Fisheries	Grand Manaan, N.B.	Ocean Water Source	Aquatec 52Hu	- Single Story Fisheries Building	54
Schofield, M.	Moncton, N.B.	Swimming Pool Source and Thermal Storage + DHW Assistance	Canair CP-45W-8	- Two Story House	258
Tidehead Council	Tidehead, N.B.	Water Well Source	Aquatec 52Hu (3 units)	- Municipal Building Single Story	391
Weisseneder, K	Rothesay, N.B.	Water Well Source	Glencar	- Two Story House	223

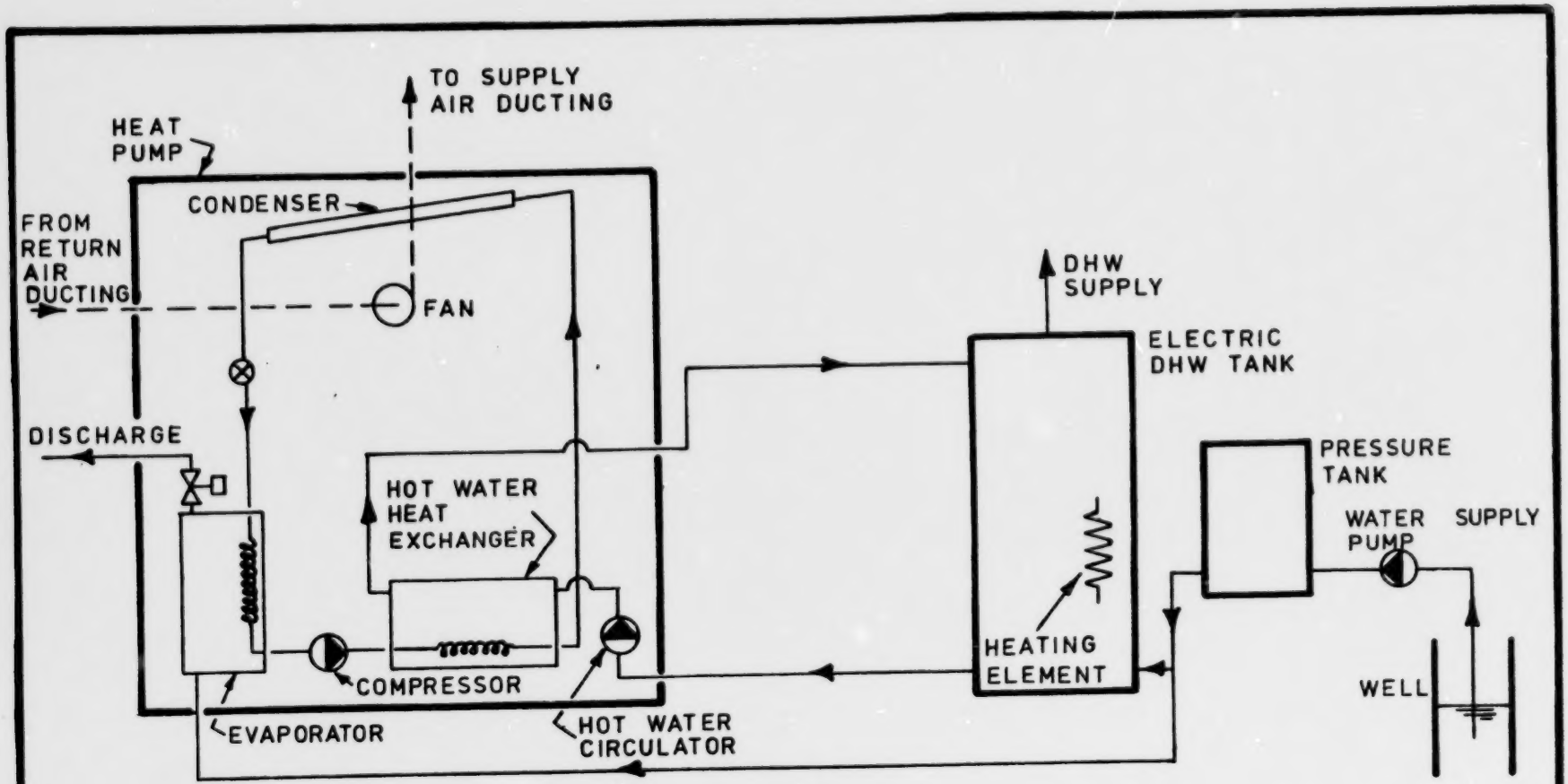


FIG. # 1

CREDA HEAT PUMP MONITORING

TYPICAL HEAT PUMP SYSTEM

4.0 Monitoring Systems Descriptions

Figure #2 - "Typical Heat Pump Monitoring System" illustrates the amount of monitoring performed in the project. This includes determining the individual consumption of the various electrical components as well as determining source heat transfer and domestic water heating assistance heat transfer. Table #A2 - "Monitoring Values Recorded" shows the extent of the monitoring at each location. The individual monitoring systems are shown in Appendix A - "Heat Pump System and Monitoring Flow Diagrams".

The Monitoring data was gathered by a manual or an automatic data gathering method. By means of a computer program, (Manin or Elecin), the input data was placed on computer disk files. The program computed all values on a daily basis to be placed in the files as such.

A computer program, (COMP), was created to take the data from the input files and calculate the required resultant values. The resultant values, (calculated on a daily basis) were placed in other files. Thus the disk for each proponent included input (*.INP) and resultant (*.RES) files.

Other computer programs, (PRIN and PROUT), were created to transfer input and output data to Tables as and when required. The values from the Tables were used to prepare the graphs shown in this report.

Manual Data Gathering. Figure #3 - "Manual Data Gathering Schematic" shows the steps taken in processing the data under this method. First, input data sheets are filled out on a daily or weekly basis by the proponent. A typical input data sheet is shown in Figure #4. Approximately each month the sheets were sent to Adsett & Associates where the data was typed into the computer for disk storage. As mentioned previously, a computer program "Manin" created input files of values on a daily basis.

Automatic Data Gathering. Figure #5 - "Automatic Data Gathering Schematic" illustrates the steps taken to gather and assimilate the data in a completely automatic manner. As part of this project a local electronics development firm, Holman Controls Limited, was retained to produce four automatic data gathering units to the requirements of the project.

The data gathering units have the capability of recording up to eight temperatures and sixteen events. The information is placed on cassette disk. Event pulses are accumulated, recorded to cassette and reset each hour. Temperatures are recorded each hour as well. In order to determine heat transfer accurately the first two events will activate the recording of the first four temperature inputs only when pulsing from the respective flow meter occurs. The first event controls the first two temperature inputs and the second event controls the third and fourth temperature inputs. As well, the number of minutes that each of the two events was active during the hour is recorded. Since the temperature gathering is cumulative the actual temperatures can be determined by dividing the resultant values by the number of minutes that the flow meter was active. The reason for this procedure is to allow for the accurate determination of two different heat transfers (ie. each requires one flow meter, a pulsed event, and two temperatures - inlet and outlet).

Recording data on an hourly basis takes approximately one week for one side of the cassette to become full. It was then sent to Adsett & Associates Ltd. where it was placed in a translator and the data transferred to computer disk. By the use of a computer program, (ELECIN), the data is checked and reduced from hourly to daily values and placed in input files. As was performed under the manual data gathering method, calculations are now completed, resultant value files created and printouts performed as required. Printouts can be for any length of period that there is input data for and can be given on a daily or a monthly basis.

Appendix F - "Computer Data" shows printouts from this project.

Table #A3 - "Monitoring Values Determined by Computer" gives a listing of the values placed in tabular form by the computer. Appendix E - "Equations used in Calculations" gives the backup for the determination of these values. It should be noted that the difference between Coefficient of Performance and Performance Factor has to do with unit and system performance. Coefficient of Performance applies only to operation of the unit whereas Performance Factor includes the total system energy requirements. The main difference between the two is in the energy required by the liquid source pump (ie. water well circulator, etc.). It should be noted that total heating by heat pump does not include the supply pump whereas electric to heat pump does include this value.

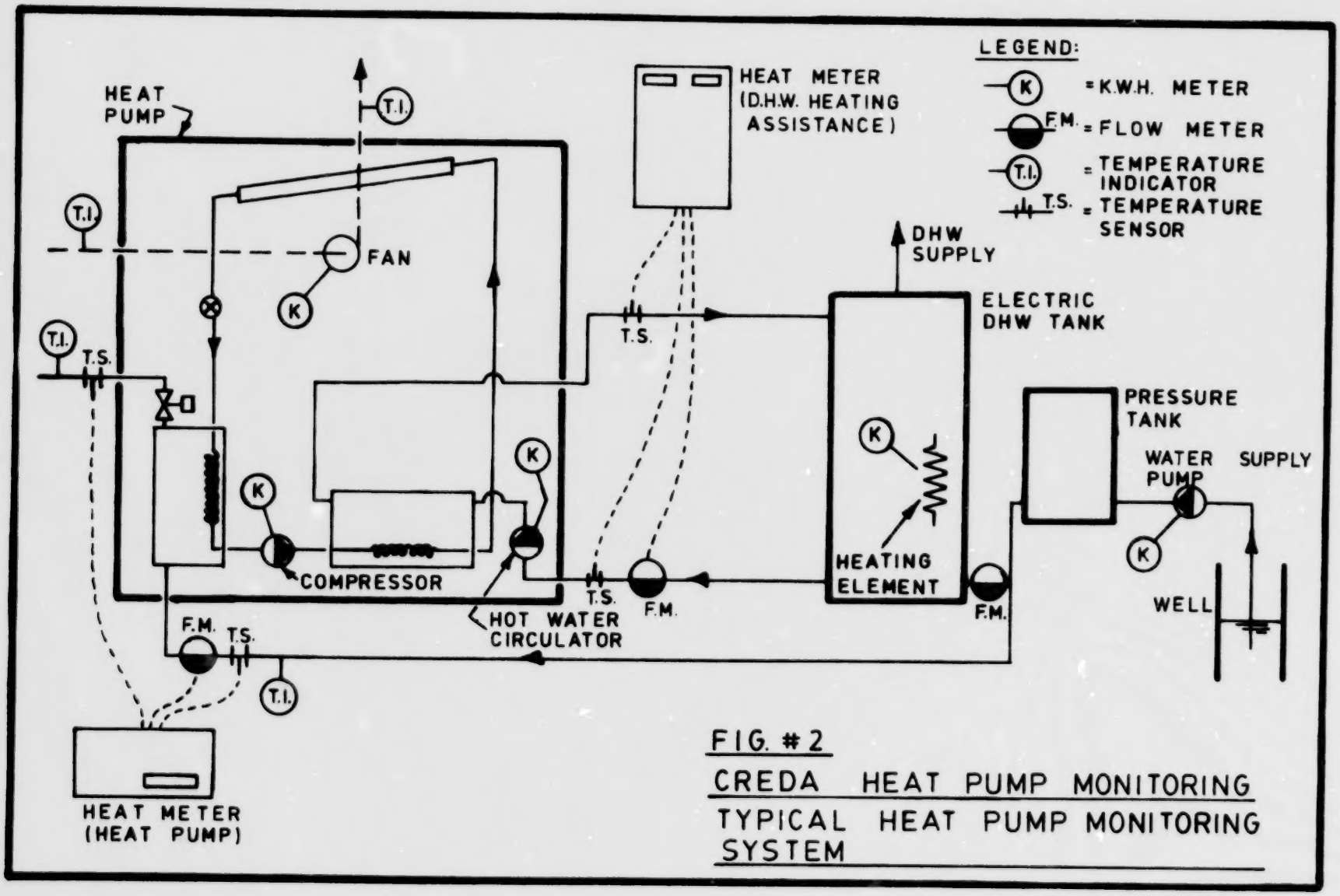


FIG. # 2

CREDA HEAT PUMP MONITORING

TYPICAL HEAT PUMP MONITORING SYSTEM

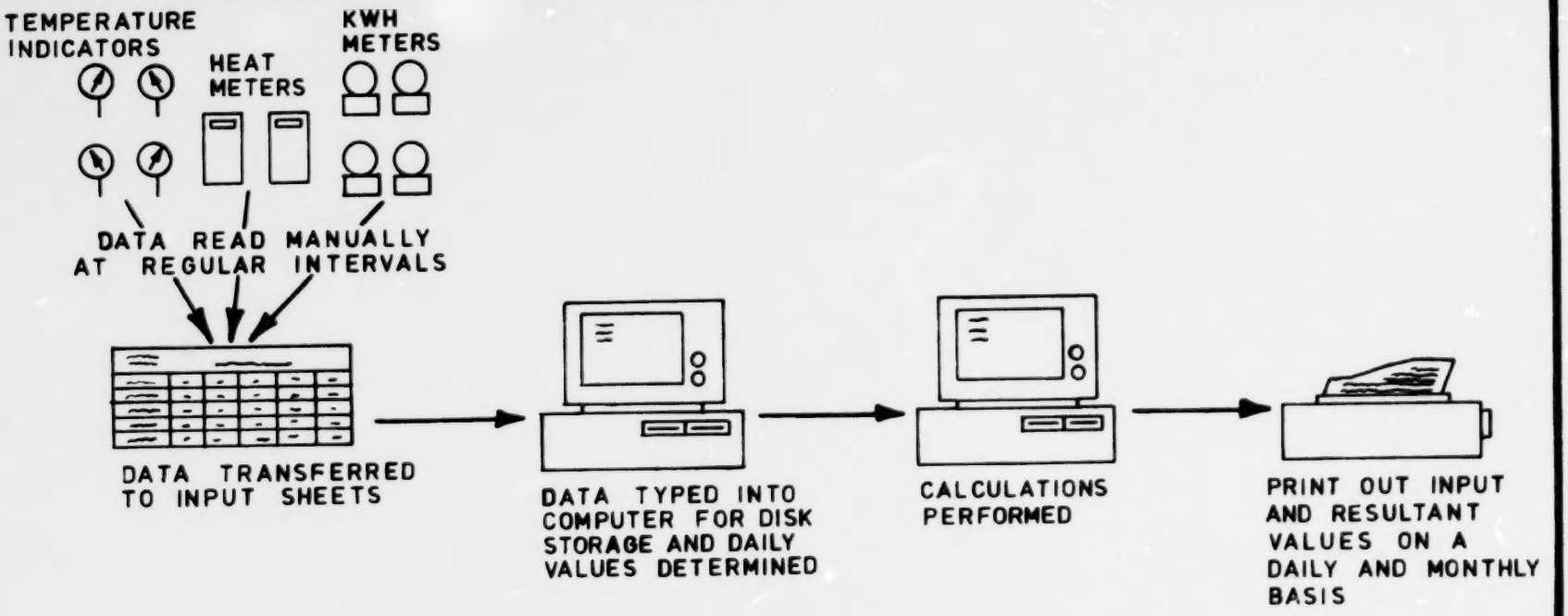

TEMPERATURE INDICATORS
HEAT METERS
KWH METERS
DATA READ MANUALLY AT REGULAR INTERVALS
DATA TRANSFERRED TO INPUT SHEETS
DATA TYPED INTO COMPUTER FOR DISK STORAGE AND DAILY VALUES DETERMINED
CALCULATIONS PERFORMED
PRINT OUT INPUT AND RESULTANT VALUES ON A DAILY AND MONTHLY BASIS

FIG. # 3
CREDA HEAT PUMP MONITORING
MANUAL DATA GATHERING
SCHEMATIC

FIGURE # FOUR - TYPICAL INPUT DATA SHEET

Name:_____ From:_____ To:_____

DATE	KWH METERS								TEMP. INDICATORS (deg. C)				HEAT METER				FLOW
	DHW TANK	DHW PUMP	FAN	COMP	CIRC PUMP	HOUSE	AUXILIARY HEAT #1	AUXILIARY HEAT #2	WATER IN	WATER OUT	AIR IN	AIR OUT	TO HP BTU x 1000	TO HP Gal.	TO DHW BTU x 1000	TO DHW Gal.	DHW Gal.

COMMENTS FOR PERIOD:

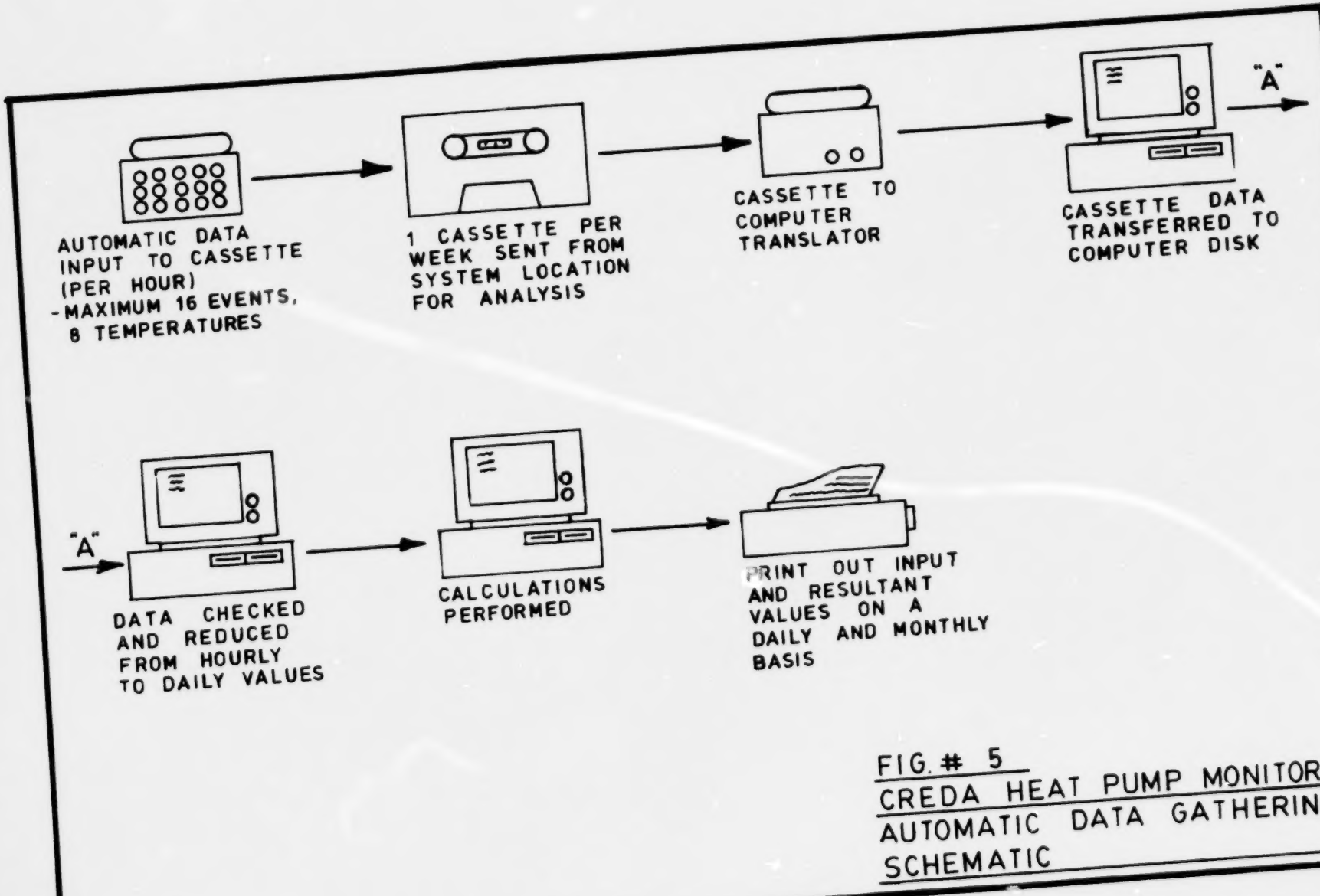

AUTOMATIC DATA INPUT TO CASSETTE (PER HOUR) - MAXIMUM 16 EVENTS, 8 TEMPERATURES
1 CASSETTE PER WEEK SENT FROM SYSTEM LOCATION FOR ANALYSIS
CASSETTE TO COMPUTER TRANSLATOR
CASSETTE DATA TRANSFERRED TO COMPUTER DISK
"A"
"A"
DATA CHECKED AND REDUCED FROM HOURLY TO DAILY VALUES
CALCULATIONS PERFORMED
PRINT OUT INPUT AND RESULTANT VALUES ON A DAILY AND MONTHLY BASIS

FIG. # 5
CREDA HEAT PUMP MONITORING
AUTOMATIC DATA GATHERING
SCHEMATIC

5.0 Observations Concerning Monitoring

Due to the energy cost savings of the water source heat pump and its increasing use, not only in New Brunswick, but across Canada, it was the intent of this project to determine in as accurate a manner as feasible, the energy and economic viabilities of the systems. Therefore, the monitoring installed was relatively extensive. The problems encountered in this project will help in the execution of future similar monitoring work.

In order to ensure the accuracy of the automatic data gathering system, a test bench was built. Each unit was connected to the bench and data gathered. Since the data could be read manually as well, the values recorded by the system were varified. Several software problems within the automatic data gathering system were corrected in this manner before the units went on site.

Although pulse flow meters were ordered with the stated capability of withstanding high temperatures a number of meters failed on the domestic hot water lines. Thus, it was only possible to get information concerning domestic water heating assistance from two of the heat pump systems. (Gallant and Flewelling).

The number of pulses per unit volume that the flow meters delivered was stated inaccurately. This was found out and corrected before errors were introduced to the input data. It is suggested that pulse flow meters also have a readable dial so that the pulses per unit volume can be verified.

A high percentage of the heat meters failed to operate as required. One of the main problems was the counters not moving on impulse. L.E.D. readouts would be more reliable.

It was found that reliance on the unit owner for data reading is not always a accurate method. One of the proponents listed did not give any readings. The only values known were those recorded during system installation and another set read just before monitoring system dismantling. Another proponent, not listed in this report, refused to operate any monitoring equipment and thus no values could be obtained. It is believed that if at all possible automatic data gathering should be used to remove these obstacles and also to give more accurate and reliable values. As well, automatic data gathering occurs at a shorter time interval than the manual method and therefore, momentary changes in system characteristics can be studied.

6.0 Performance Summary

In order to determine system performance as much data as possible was collected. If values could not be obtained to cover a complete year, calculations were performed based on unit values determined from the known quantities. Table #A4 - "Monitoring Period Used" indicates the periods when reliable data was available from each proponent.

Table #2 and Graphs numbered B1 to B4 inclusive - "Energy & Cost Savings" give overall resultant values. The Graphs are scaled such that total heat pump energy supply equals 100%. Since the Schofield system is not intended to save a considerable amount of energy while space heating occurs, its performance will be discussed separately from the rest. Values for all other systems are on an annual basis derived from monitored data and calculated values. Energy costs are assumed at $0.0427/KWH.

It can be seen from the Graphs that percentage savings range from 44 % to 58 %. One reason for the difference in savings between the various proponents is the amount of energy required for water pumping. This requirement ranges between 1,554 KWH and 5,541 KWH. Another factor is temperature of the inlet heat source (water - glycol/water mixture). Graph #B5 - "COP Verus Evaporator Inlet Temperature" illustrates that there is a general increase in Coefficient of Performance for an increase in evaporator inlet temperature. At an inlet temperature of -2 to -4 Deg.C. the Coefficient of Performance is low. The low temperature data all occured in the Flewelling system, since heat transfer was from the river through the means of a glycol/water loop.

Graphs numbered B2 & B3 give values concerning domestic water heating energy use and assistance by the heat pump for the Flewelling and Gallant systems. By referring to Graph #B6 - "Domestic Water Heating Assistance" we can see that although energy contribution from the heat pump to the Gallant system was considerably higher than that to the Flewelling system the overall energy use by the Flewelling system was less. The values concerning total savings and energy use include those applicable to DWH assistance.

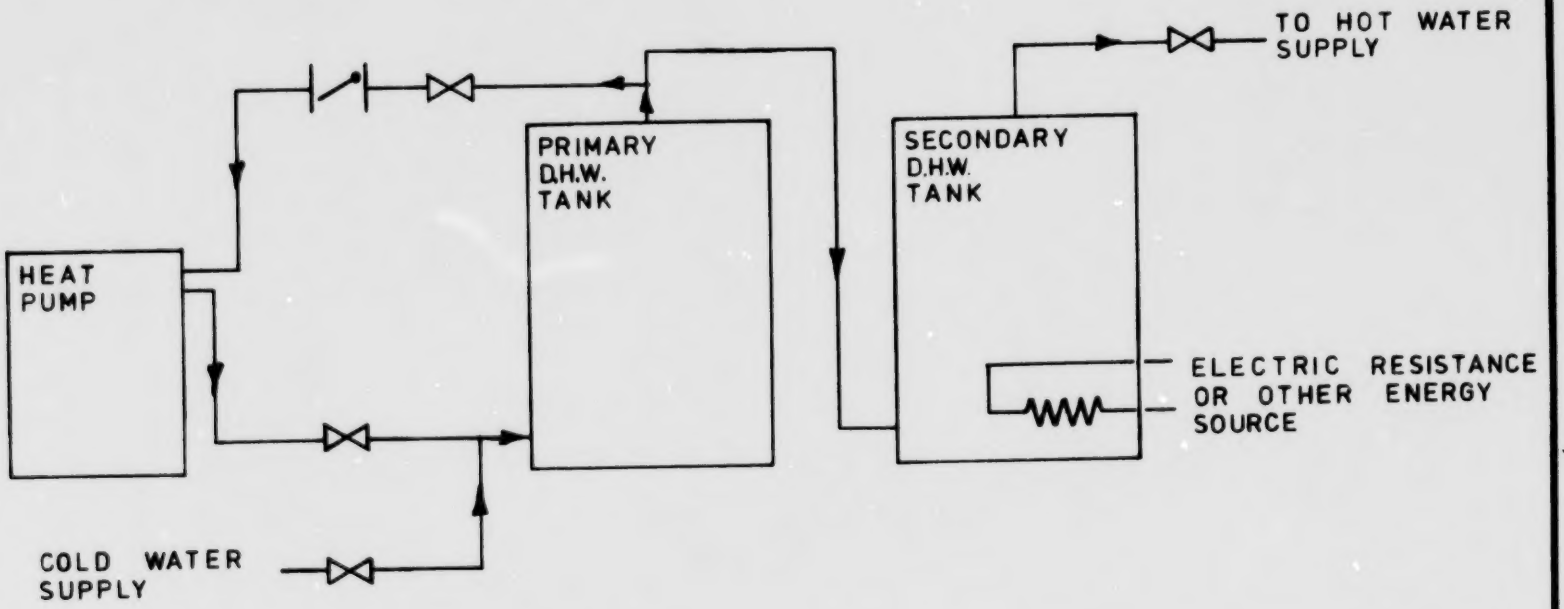
It is suggested that the full use of the heat pump DWH assistance is not utilized when one tank is used for both heat pump energy input and auxiliary heating input. This is also seen by the fact that another proponent, K. Weisseneder, did not use any domestic water auxiliary heating during portions of the space heating season. Due to the breakdown of the domestic water meter, actual hot water assistance values for the Weisseneder system were not determined. It is suggested that a more applicable system for domestic water assistance be as shown in Figure #6 - "Heat Pump Assisted DHW Heating Diagram". The use of two tanks with the heat pump connected to the primary tank allows the transfer of heat from the heat pump to domestic water to be the primary input with elecytric/oil heating as secondary.

It would be inaccurate to compare directly the results obtained from the Schofield system with the others. This is because the heat source for the heat pump for space heating is the indoor swimming pool which is heated in turn by the pool heater. Values that can be compared are the coefficient of perfromance and the performance factor which were 1.06 and 2.47 respectivly. A total years data for this system could not be calculated since the unit consumption varied considerably. Therefore the most values shown are those measured. It should be noted that there appeared to be a slight energy savings, (268 KWH's - 6%). This could be due to passive solar input. In order to determine the real benefits of this system concerning space heating the characteristics of the pool energy requirement without heat pump operation must be known. It was impossible to obtain this during the monitoring period used.

Table Two
Energy Usage and Saving Results

Proponent	Period	Component Energy Use (KWH)				Total Electric (KWH)	Total Output (KWH)	Savings (KWH)	Coeff. of Perform.	Performance Factor
		Water Supply Pump	Compressor	Domestic Water Pump	Blower					
Deschenes Drilling	Annual	3,270	15,039	N/A	1,931	20,240	47,978	27,738	2.83	2.37
Douglas #1	"	3,494	Total = 11,872			15,366	35,593	20,227	3.00	2.32
" #2	"	3,465	Total = 11,916			15,381	34,094	18,714	2.86	2.22
Flewelling	"	1,737	8,287	141	848	11,013	19,580	8,567	2.11	1.78
Gallant	"	2,508	4,338	233	575	7,654	15,039	7,384	2.92	1.97
Hooper	"	1,554	3,746	-	396	5,696	12,084	6,388	2.92	2.12
Little Rock Fish	No Data At Present ---									
Schofield	partial year	284	1,256	pool heat 2,410	284	4,234	4,502	268	2.92	1.06
Tidehead Council	Annual	5,541	Total = 14,243			19,784	42,279	22,495	2.97	2.14
Weissenederer	"	3,495	9,750	128	845	14,219	29578	15,359	2.76	2.08

NA - Not Available
N/A - Not Applicable



LEGEND:

= CHECK VALVE

= GATE VALVE

FIG. # 6

CREDA HEAT PUMP MONITORING

HEAT PUMP ASSISTED D.H.W. HEATING DIAGRAM

7.0 Cost/Benefit Analysis

Table #3 - "Cost/Benefit Results" gives total system costs, annual cost savings and simple payback for each proponent. The annual cost savings are based on a energy cost of $.0427/KWH for electricity and $0.391/l for oil. These values will no doubt rise making the payback period less in each case.

In order to determine payback periods, the units were compared to oil fired space heating systems. Thus, energy savings consider the difference between gross oil/electric use in an oil fired system to electric energy use in a heat pump system. The net/gross energy use factor for the oil fired systems was derived from values measured concerning direct oil to electric conversions in a report by Prof. V. M. Ireton, P.Eng. entitled, "Measurement of Energy to Heat Houses, Phase III".

Two payback periods are given for each proponent; total and incremental. The total payback period considers the total cost of the installed system while the incremental considers that difference between the heat pump system cost and the assumed cost of a oil fired system.

The total system heat pump costs are the actual costs spent on each project. It should be noted that if the systems were not experimental in nature and were considered conventional installations, the amounts would probably be less. As well, the costs concerning well drilling, or circulating heat source systems were separated for further clarification.

Except in the case of Deschenes Drilling, the replacement system cost does not include air conditioning. Air conditioning is still considered a luxury in this area and most of the heat pumps tested did not have air conditioning abiblity. The Deschene unit did have air conditioning ability and space cooling would no doubt have been provided since the house was partially office.

Total and incremental paybacks ranged from 3.8 to 26.6 years and 0.9 to 21.6 years respectively. The wide range indicates that system installation costs and capacity factors varied considerably. The lower values show that the systems can be economical. The low paybacks apply to houses using much energy causing the systems to run more and allowing for greater energy and cost savings.

Table Three
Cost/Benefit Results

Proponent	Well Drilling Cost, ($)	Heat Pump Cost, ($)	System Total Cost, ($)	Assumed Cost of Conv. System, ($)	Incremental Cost of H.P. System,	Energy Savings*** (KWH/Yr)	Energy Cost Savings*** ($)	Payback Period Total* (yrs)	Payback Period Inc.** (yrs)
Deschenes Drilling	5,650.00	8,894.00	14,544.00	12,336.00	2,208.00	67,761.42	2,348.77	6.19	0.94
Douglas # 1	1,150.00	5,200.00	6,350.00	3,332.00	3,018.00	49,219.51	1,692.98	3.75	1.78
Douglas # 2	1,150.00	5,200.00	6,350.00	3,332.00	3,018.00	46,248.78	1,584.84	4.01	1.90
Flewelling	2,623.50	8,210.50	10,834.00	3,356.00	7,478.00	24,030.17	809.70	13.38	9.24
Gallant	2,390.00	3,526.00	5,916.00	2,780.00	3,136.00	16,975.33	572.63	10.33	5.48
Hooper	4,100.00	3,978.00	8,078.00	2,100.00	5,978.00	15,090.34	515.33	15.68	11.60
Little Rock Fisheries	Monitoring Data Not Available at Present								
Schofield			11,031.00	Economics determination not applicable for space heating. System savings are in the transfer of air conditioning heat to pool					
Tidehead Council	6,737.00	42,378.00	49,115.00	9,300.00	39,815.00	54,135.52	1,843.83	26.64	21.59
Weisseneder	2,099.00	6,365.00	8,464.00	3,776.00	4,688.00	37,276.13	1,272.00	6.65	3.69

* Total Payback consider total installed system cost.
** Incremental Payback considers the difference between the heat pump system costs and the assumed cost of an oil fired heating system.
*** Energy and cost savings assume oil space heating versus heat pump

8.0 Discussion of Results

It should be noted that the system installed by M. Schofield uses an internal heat source (the swimming pool) which requires heating by electric energy. The only savings in space heating in this system can be attributable to passive solar gain. The real advantage of the Schofield system is in an air-conditioning application where the heat can be transferred to the swimming pool, thus causing a reduction in swimming pool water heating. This advantage could not be tested since the swimming pool was not large enough to absorb all of the air-conditioning heat and there was no dissipation exterior to the house. Thus the water temperature would become unacceptably high and the heat pump system had to be shut down.

Graphs numbered B1 to B4 inclusive - "Energy and Cost Saving Results" indicate that a considerable amount of total energy use is attributable to the water pump. Because a domestic supply pump must increase water pressure for house supply, a pump separate from the regular domestic pump should be used for the heat pump unit. In this way, additional energy is not required to increase and then dissipate the pressure. The additional pump could be connected directly to the heat pump unit.

It can be seen from Graph #B6 - "Domestic Water Heating Assistance" that the effect of the heat pump on domestic water heating can be low. As stated previously, the use of primary and secondary heating tanks as shown in the Flow Diagram - Figure #5 would eliminate this problem.

Inlet heat source temperature effects the overall energy savings. This is seen in Graph #B5 - "COP Versus Evaporator Inlet Temperature". Where the temperature falls below -2 deg. C, the advantage of the heat pump is low. However, the temperature spread of the heat source over a complete year should be known in order to evaluate the total effectiveness of the system.

9.0 Conclusions and Recommendations

The seasonal Performance Factor ranged from 1.06 to 2.47 while the seasonal heat pump Coefficient of Performance ranged from 2.11 to 3.00. System installation cost varied from $5,916 to $49,115, (3 units), and incremental payback was between 0.9 and 26.6 years.

The major factors affecting energy savings appeared to be due to inlet source temperature, water pump consumption and overall energy consumption requirements. The system will save more energy and thus be more attractive economically if the inlet source temperature is relatively high, the ground water table is high, and there is a high space heating energy requirement.

If water supply could be a problem or if unit cost is considerably higher for a large unit, it is suggested that the heat pump be undersized and that additional heating requirement be made through auxiliary heaters (ie. in-duct electric resistance, etc.). In this way the demand for water will be less, the unit's efficiency should increase due to a higher capacity factor and initial cost could be less.

If domestic water assistance is provided by the heat pump it is recommended that two domestic hot water tanks be installed and that the first be connected to the heat pump unit and the second provide auxiliary heat as required to increase the temperature to the desired set point. This is seen in Figure # 6 - Heat Pump Assisted DHW Heating Diagram.

Additional monitoring should be performed to evaluate the attractiveness of the domestic water heating assistance portion of the heat pump. This monitoring should consider the use of a system such as described above.

Concerning the operation of a monitoring program it is recommended that if possible all components be tested before being placed on site. In this way the problems due to equipment breakdown will be minimized and the accuracy of the monitoring system evaluated before reliable operation is required.

In order to determine the feasibility of using air-conditioning heat transfer to a swimming pool, additional monitoring should be performed since the Schofield system had to be shut down frequently due to the inability of the swimming pool to dissipate all the heat.

The results obtained by the Hooper system illustrate that it is possible to recharge the same well as the water was supplied from. However, this monitoring only considered the above ground heat pump system. It would be advantageous to examine a considerable number of systems using the same wells for supply and discharge and to determine the overall thermal effect on the ground and ground water temperature for various aquifer configurations and ground water supply temperatures. The advantage of this type of configuration is the fact that no water is taken from the ground water system without being reentered.

It would be useful to design, install and monitor a water source heat pump system using a closed circuit loop within a suitably sized water well. A heat exchanger located below ground could cause the transfer of energy to the heat pump without disturbing water flow within the aquifer system.

It is advantageous to use an automatic data gathering system where possible, since this allows for investigation of momentary (non steady-state) characteristics, increases the accuracy and the reliability of the data gathering and ensures continuous information transfer with short time intervals.

WATER SOURCE HEAT PUMP MONITORING

IN

NEW BRUNSWICK

APPENDIX A - SYSTEM AND MONITORING CHARACTERISTICS TABLES

Table A1 - System Characteristics

Proponent	Heat Pump Capacity (KW)	Heat Source Flow (l/s)	Heat Source Inlet Temperature (deg. C) Min	Heat Source Inlet Temperature (deg. C) Max	Heat Source Outlet Temperature (deg. C) Min	Heat Source Outlet Temperature (deg. C) Max	Hot Air Inlet Temperature (deg. C)	Hot Air Outlet Temperature (deg. C)
Deschenes Drilling	23.45	NA	6.0	6.5	3.0	5.0	20.9	41.1
Douglas #1	15.24	.79	NA	NA	NA	NA	NA	NA
" #2	15.24	.81	"	"	"	"	"	"
Flewelling	11.72	NA	-4.5	14.5	-7.0	10.5	17.5	34.3
Gallant	11.14	.44	5.2	11.7	4.1	11.2	20.2	30.2
Hooper	15.24	NA	NA	NA	NA	NA	NA	NA
Little Rock Fish	15.24	"	"	"	"	"	"	"
Schofield	13.19	.22	16.6	30.9	8.5	35.3	20.1	33.0
Tidehead Council	3 @ 15.24	3.0	3.0	4.0	1.0	2.0	16.3	NA
Weisseneder	14.65	.60	6.4	13.1	3.4	9.2	19.0	33.0

NA - Not Available

Table A2

Monitoring Values Recorded

Proponent	KWH METERS							TEMP. INDICATORS (deg. C)				HEAT METER		FLOW DHW	DATA INPUT METHOD & FREQ.
	DHW TANK	DHW PUMP	FAN	COMP	SUPPLY PUMP	HOUSE	AUX. HEAT	WATER IN	WATER OUT	AIR IN	AIR OUT	TO HP BTU x 1000.	TO DHW BTU x 1000.	Gal.	(#/TME)
Deschenes Drilling	-	-	X	X	X	X	-	X	X	X	X	X	-	-	Manual (1/wk)
Douglas #1	X	-	Total		X	X	-	X	X	X	X	X	-	-	Manual
" #2	N/A	-	Total		X	-	-	X	X	X	X	X	-	-	(1/dy)
Flewelling	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Manual (1/4dy)
Gallant	X	X	X	X	X	-	-	X	X	X	X	-	-	X	Auto (1/min)
Hooper	X	X	X	X	X	X	-	X	X	X	X	X	X	X	Manual (1/yr)
Little Rock Fish	-	-	Total		X	-	-	X	X	-	-	X	-	-	Manual (1/dy)
Schofield	X	-	X	X	X	-	X (pool)	X	X	X	X	-	-	X	Auto (1/min)
Tidehead Council	-	-	Total		X	-	-	X	X	X	-	X	-	-	Manual (1/dy)
Weisseneder	X	-	X	X	X	-	-	X	X	X	X	-	-	X	Auto (1/min)

X - Values Recorded

Table A3
Monitoring Values Determined by Computer

1) Input Data Printout Table # 1

Date	Temperatures					Degree Days	Wind Velocity
	Water In	Water Out	Air In	Air Out	Ambient Air	Space Heat (deg.C-dys)	(Km/Hr)

2) Input Data Printout Table # 2

Date	CONSUMPTION - ELECTRIC					HEAT METERS		DHW
	Dhw Tank	Dhw Pump	Fan	Compressor	Supply Building Pump	Auxiliary	Heat Pump	Dhw	Flow

3) Resultant Data Table # 1 - General and Space Heating Results

Date	ENERGY (KWH's)				SPACE HEATING		Performance Factor	Coefficient of Performance
	Total Heat Pump	Electric to Ht Pump	Auxiliary Sp. Htg.	Additional Bldg Use	Ht. Pump Sp. Htg.	Unit Consumption (KWH/DDm2) W ht Pump	w/o Ht. Pump		

4) Resultant Data Table # 2 - Domestic Water Heating Results

Date	ENERGY (KWH'S)			COEFFICIENT OF PERFORMANCE	DHW USE (L)	UNIT CONSUMPTION (L/KWH)
	Total Heating	Ht Pump Energy	Fraction By Ht Pump			

5) Resultant Data Table # 3 - Energy and Cost Savings, (Daily)

Date	ENERGY SAVINGS (KWH)		COST SAVINGS ($)	
	Space Heating	Domestic Water Heating	Space Heating	Domestic Water Heating

Table A4

Monitoring Periods Available

Proponent	Month 1984 J	F	M	A	M	J	J	A	S	O	N	D	1985 J	F	M
Deschenes Drilling	NA	17-23	1-31	1-30	1-18	-	-	-	-	13-31	1-30	1-19	-	-	-
Douglas #1	NA	12-28	1-31	1-30	1-20	-	-	-	-	-	-	-	-	-	-
" #2	"	1-28	1-31	1-30	1-20	-	-	-	-	-	-	-	-	-	-
Flewelling	1-31	1-28	1-31	1-16	2-31	1-19	-	-	19-30	1-31	1-30	1-31	-	-	-
Gallant	NA	NA	28-31	1-30	1-28	-	-	-	-	15-23	4-24, 27-30	1-31	-	-	-
Hooper	-	-	-	-	-	-	-	-	one reading	-	-	-	-	-	one reading
Little Rock Fish	No data as yet. A report revision will show results of this work if possible														
Schofield	NA	NA	28-31	1-5, 24-30	1-2	4-15	-	-	-	-	1-30	1-31	-	-	-
Tidehead Council	-	-	-	-	-	-	-	-	-	-	5-30	1-31	1-31	1-28	-
Weisseneder	-	-	-	4-30	1-15	-	-	-	-	-	-	25-31			

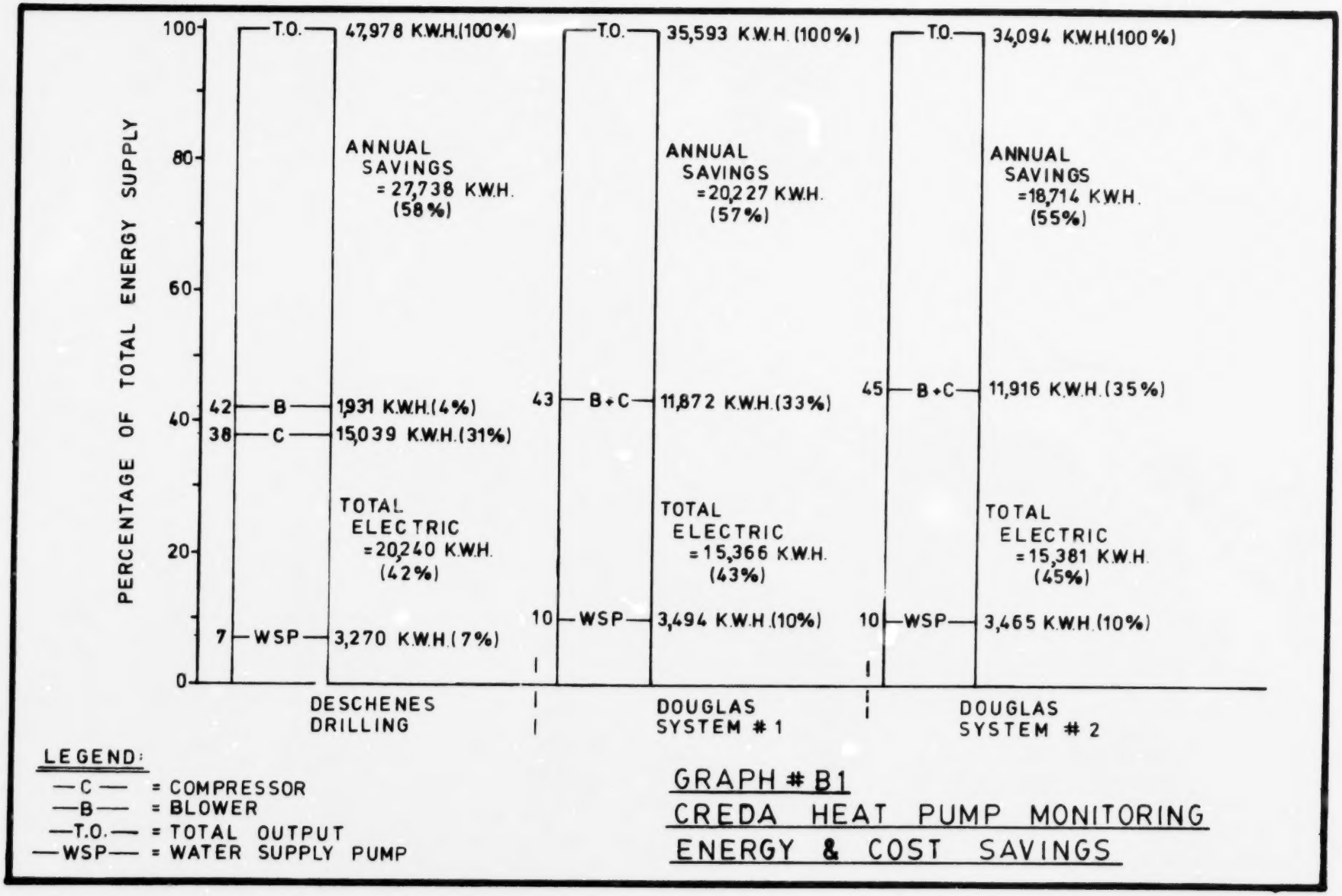
NA - Not Available

WATER SOURCE HEAT PUMP MONITORING

IN

NEW BRUNSWICK

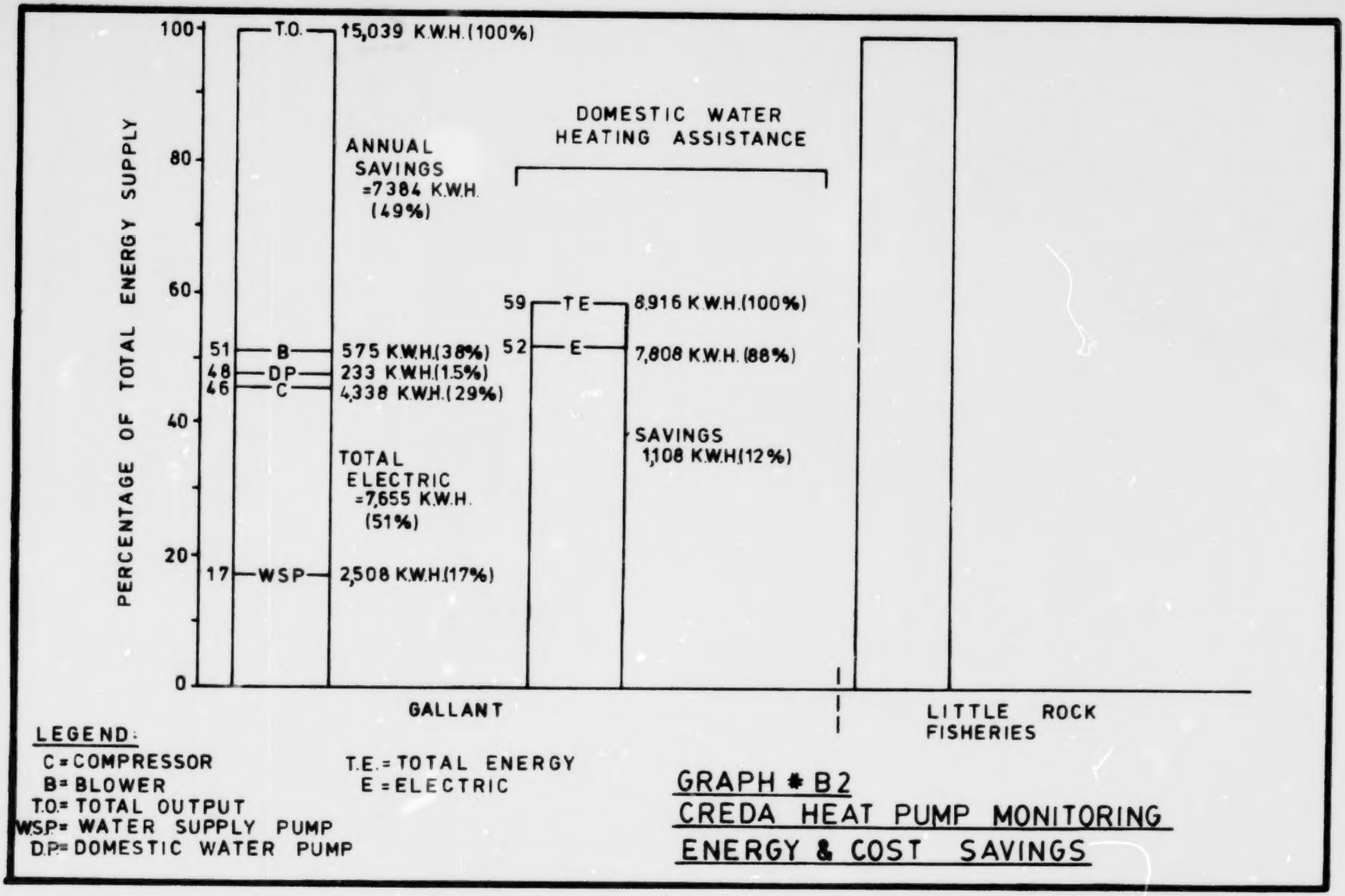
APPENDIX B - COMPARATIVE GRAPHS

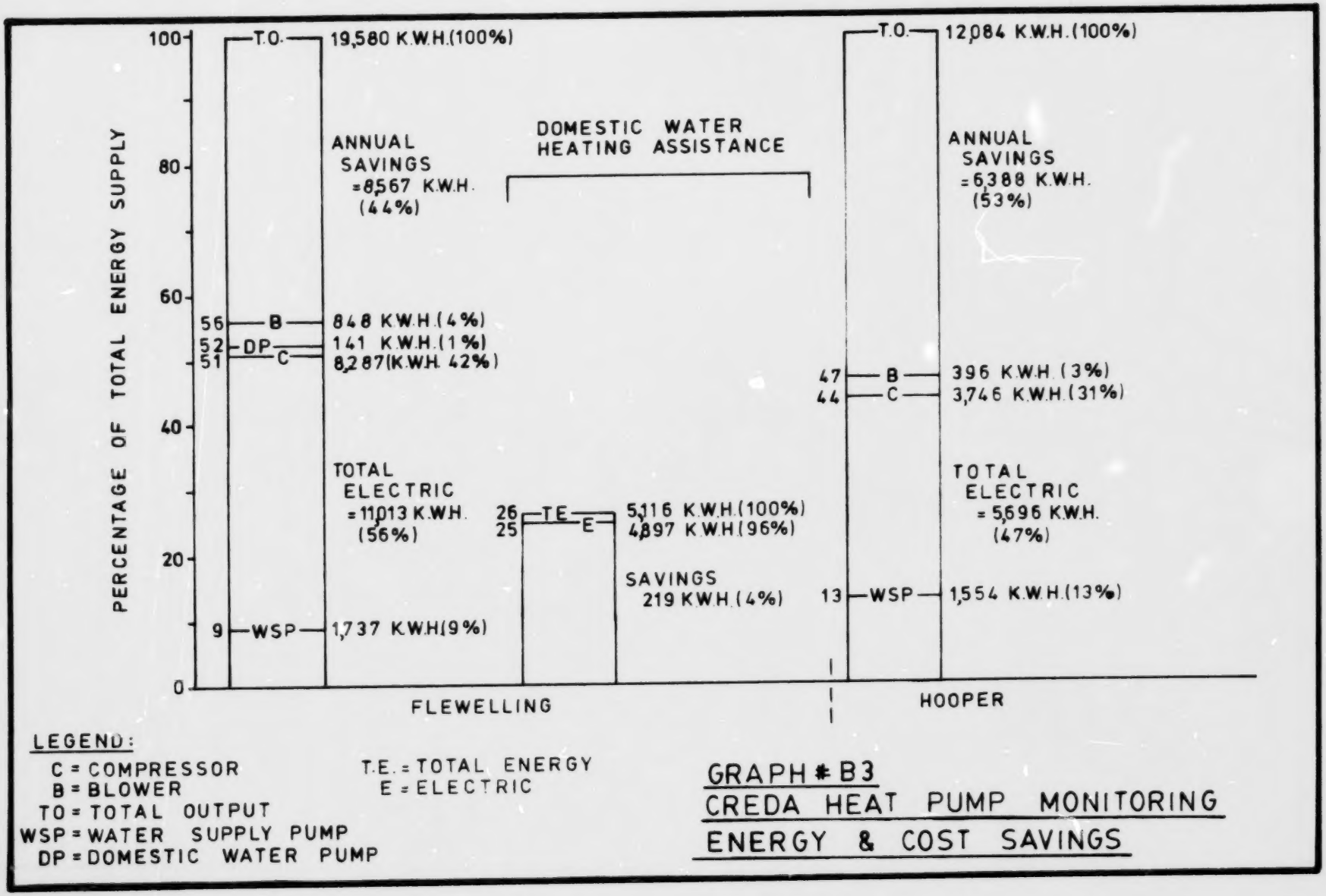


GRAPH # B1

CREDA HEAT PUMP MONITORING

ENERGY & COST SAVINGS

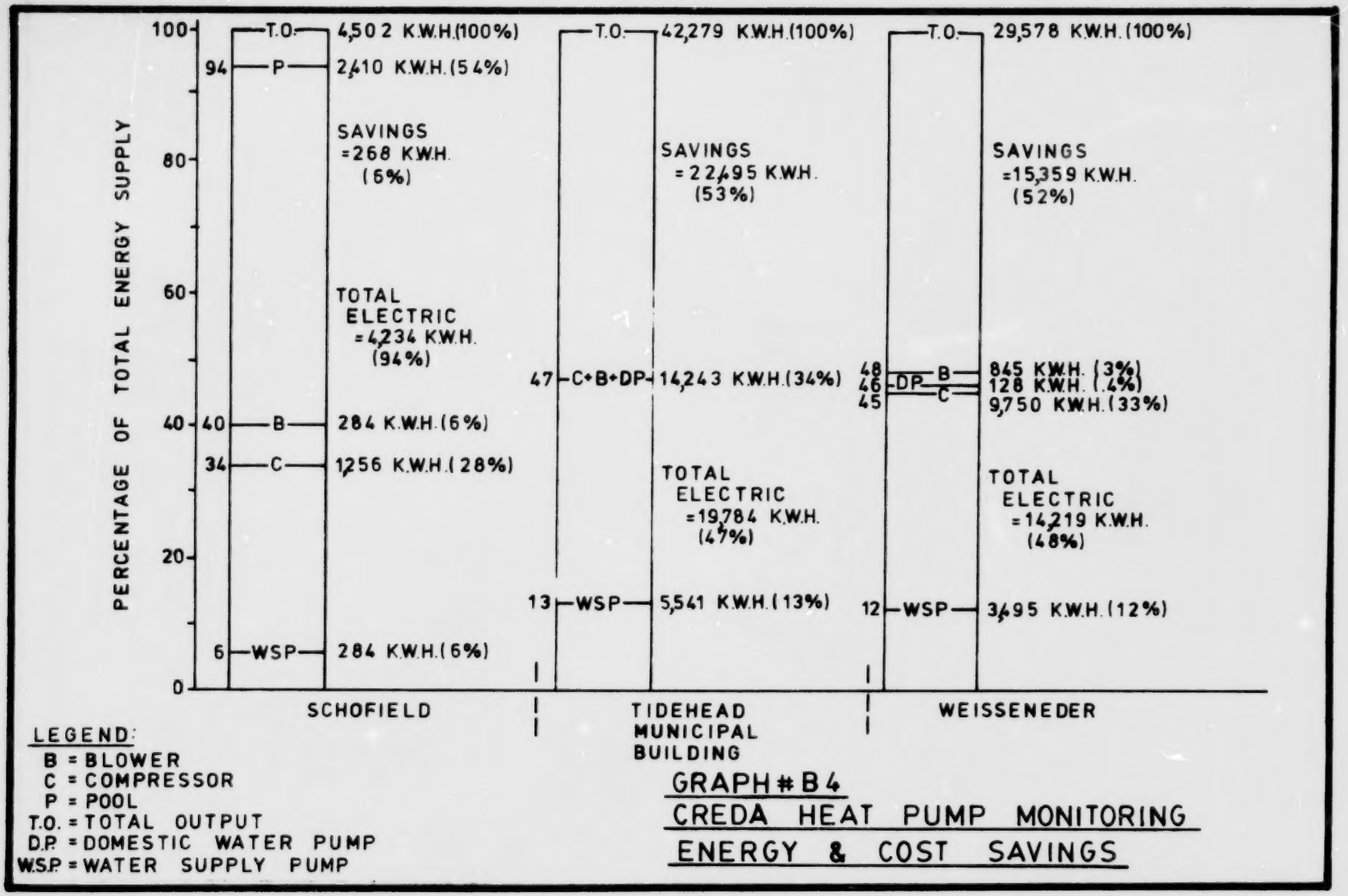

PERCENTAGE OF TOTAL ENERGY SUPPLY
100
80
60
40
20
0
T.O.
15,039 K.W.H. (100%)
ANNUAL SAVINGS =7384 K.W.H. (49%)
DOMESTIC WATER HEATING ASSISTANCE
59 T E 8,916 K.W.H. (100%)
52 E 7,808 K.W.H. (88%)
SAVINGS 1,108 K.W.H. (12%)
51 B 575 K.W.H. (3.8%)
48 DP 233 K.W.H. (1.5%)
46 C 4,338 K.W.H. (29%)
TOTAL ELECTRIC =7,655 K.W.H. (51%)
17 WSP 2,508 K.W.H. (17%)
GALLANT
LITTLE ROCK FISHERIES
LEGEND:
C = COMPRESSOR
B = BLOWER
T.O. = TOTAL OUTPUT
W.S.P. = WATER SUPPLY PUMP
D.P. = DOMESTIC WATER PUMP
T.E. = TOTAL ENERGY
E = ELECTRIC
GRAPH # B2
CREDA HEAT PUMP MONITORING
ENERGY & COST SAVINGS



LEGEND:

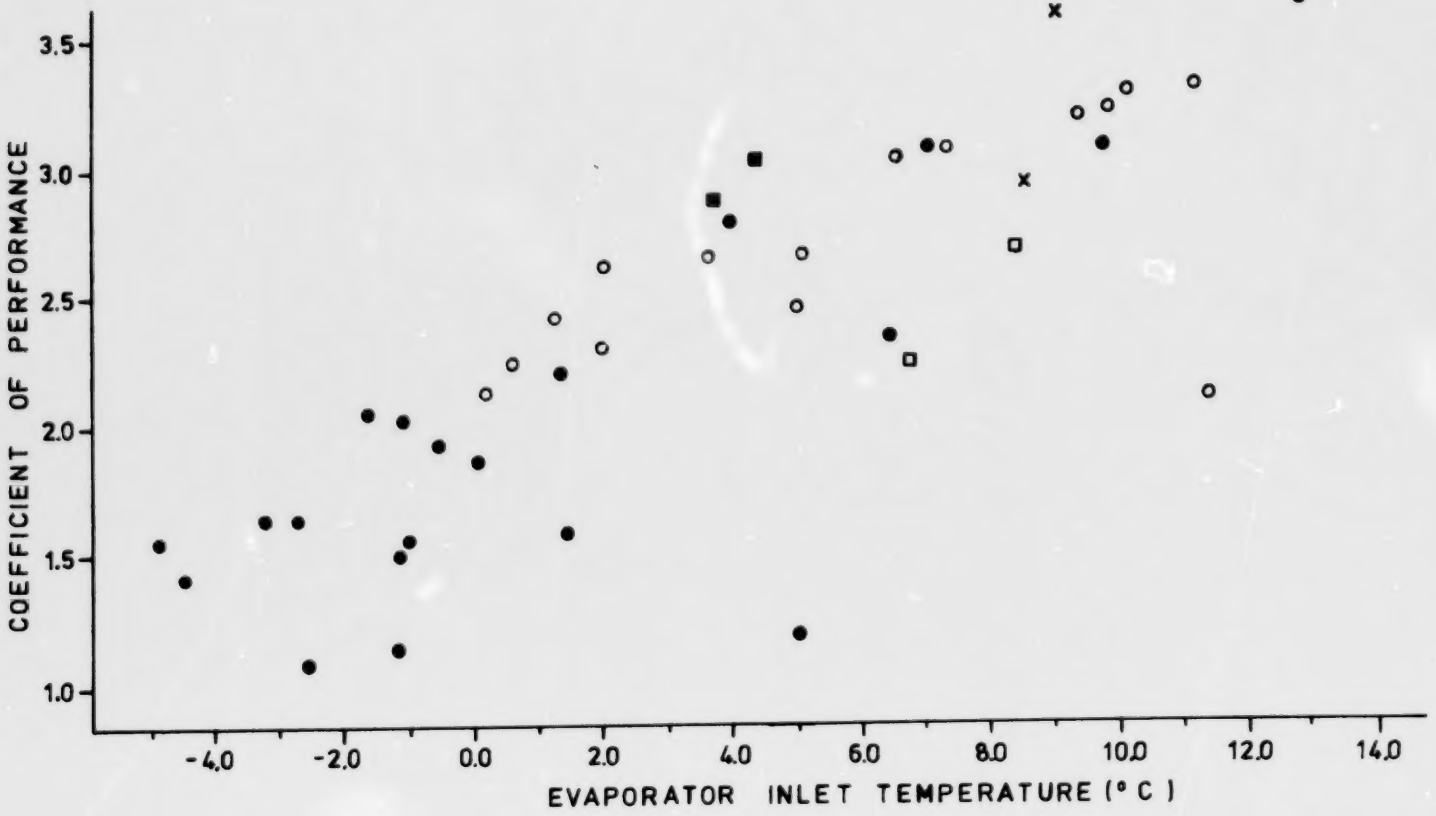
C = COMPRESSOR
B = BLOWER
TO = TOTAL OUTPUT
WSP = WATER SUPPLY PUMP
DP = DOMESTIC WATER PUMP
T.E. = TOTAL ENERGY
E = ELECTRIC

GRAPH # B3
CREDA HEAT PUMP MONITORING
ENERGY & COST SAVINGS



LEGEND:
B = BLOWER
C = COMPRESSOR
P = POOL
T.O. = TOTAL OUTPUT
D.P. = DOMESTIC WATER PUMP
W.S.P. = WATER SUPPLY PUMP

GRAPH # B4
CREDA HEAT PUMP MONITORING
ENERGY & COST SAVINGS



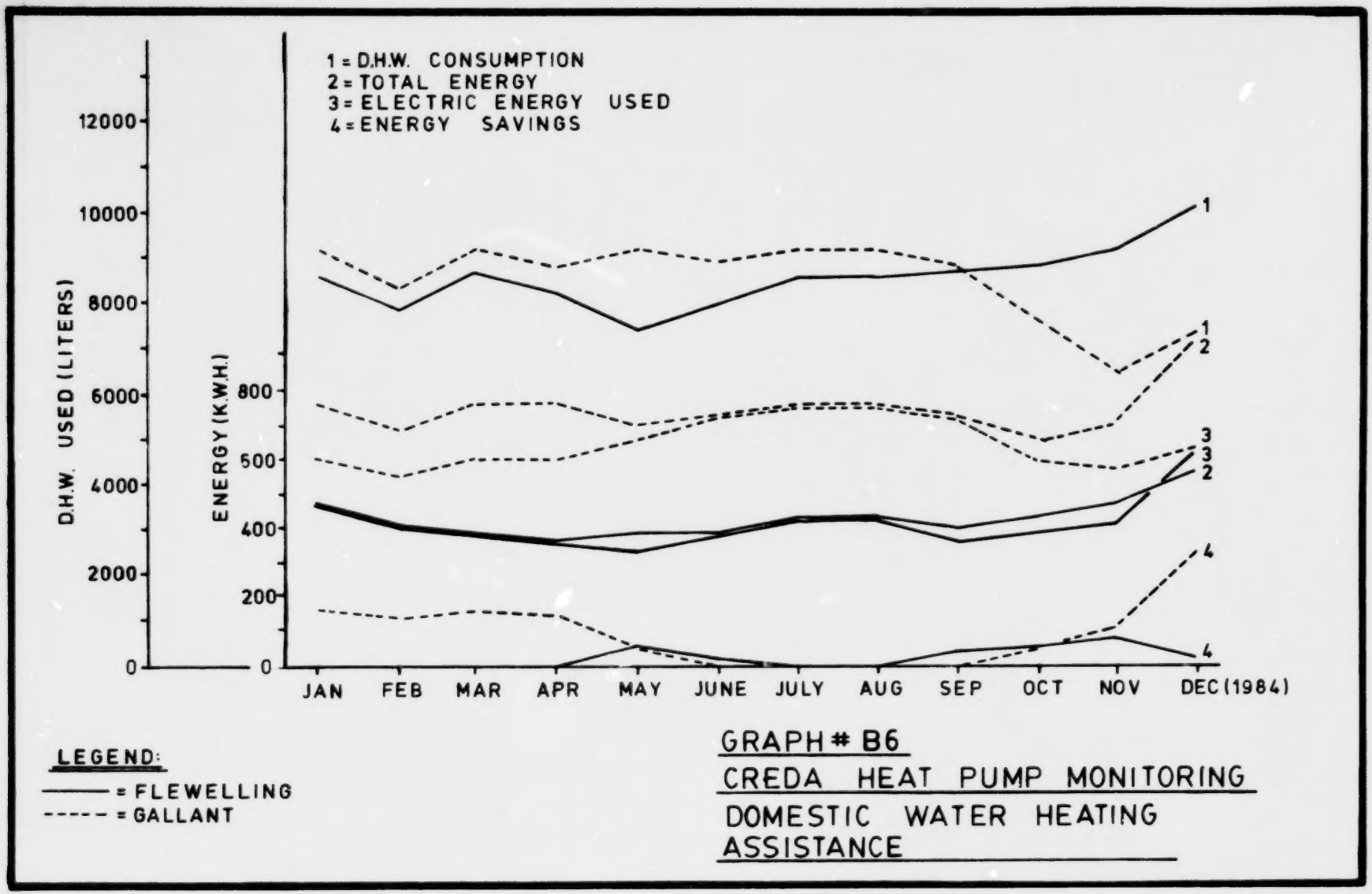
LEGEND:

- ● = FLEWELLING (1983-84)
- o = FLEWELLING (1984-85)
- X = GALLANT
- ■ = TIDEHEAD HALL
- □ = WEISSENEDER

GRAPH # B5

CREDA HEAT PUMP MONITORING

COP VERSUS EVAPORATOR INLET TEMPERATURE



GRAPH # B6

CREDA HEAT PUMP MONITORING

DOMESTIC WATER HEATING ASSISTANCE

WATER SOURCE HEAT PUMP MONITORING

IN

NEW BRUNSWICK

APPENDIX C - HEAT PUMP AND MONITORING SYSTEMS FLOW DIAGRAMS

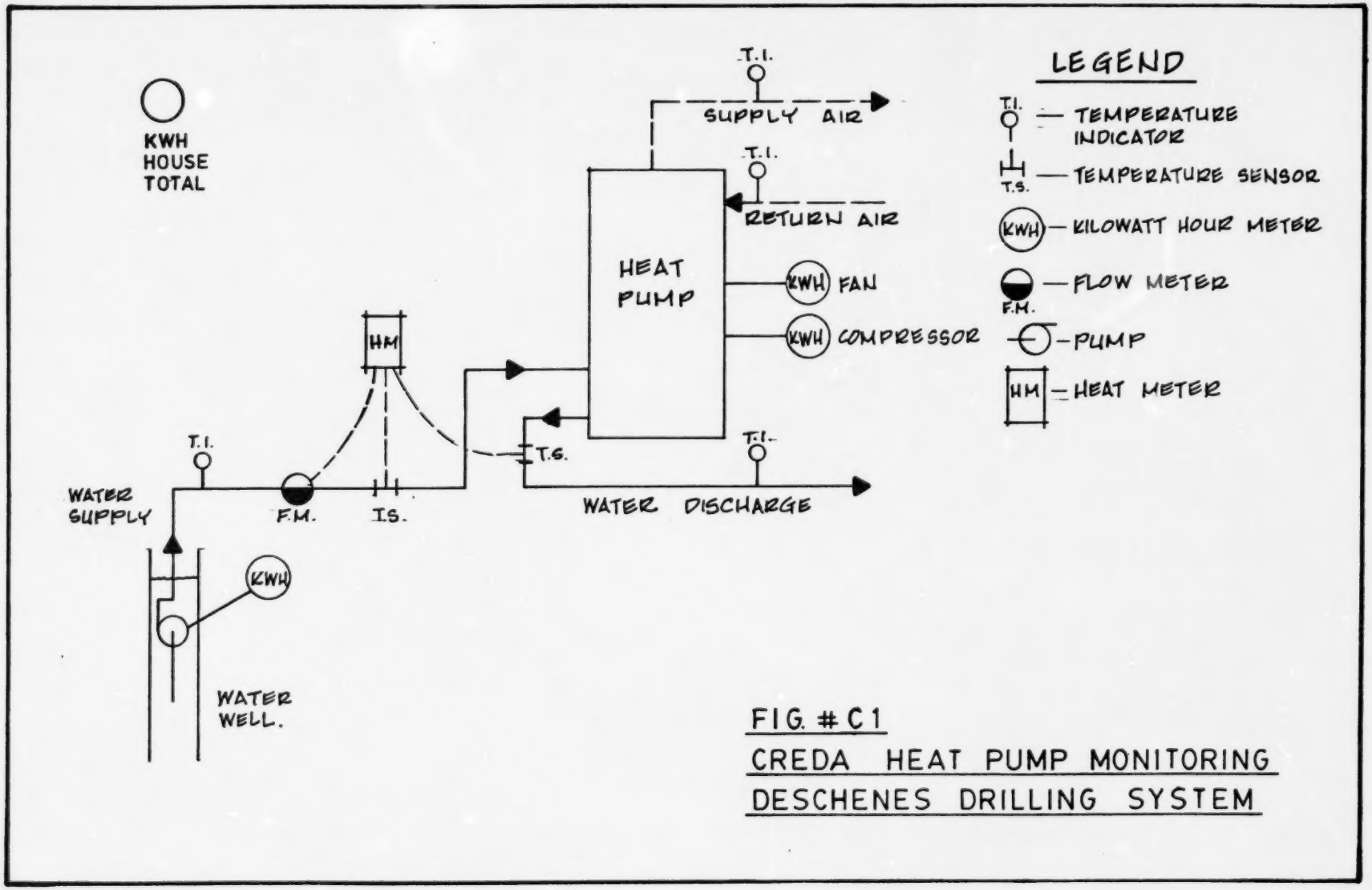


FIG. # C1

CREDA HEAT PUMP MONITORING

DESCHENES DRILLING SYSTEM

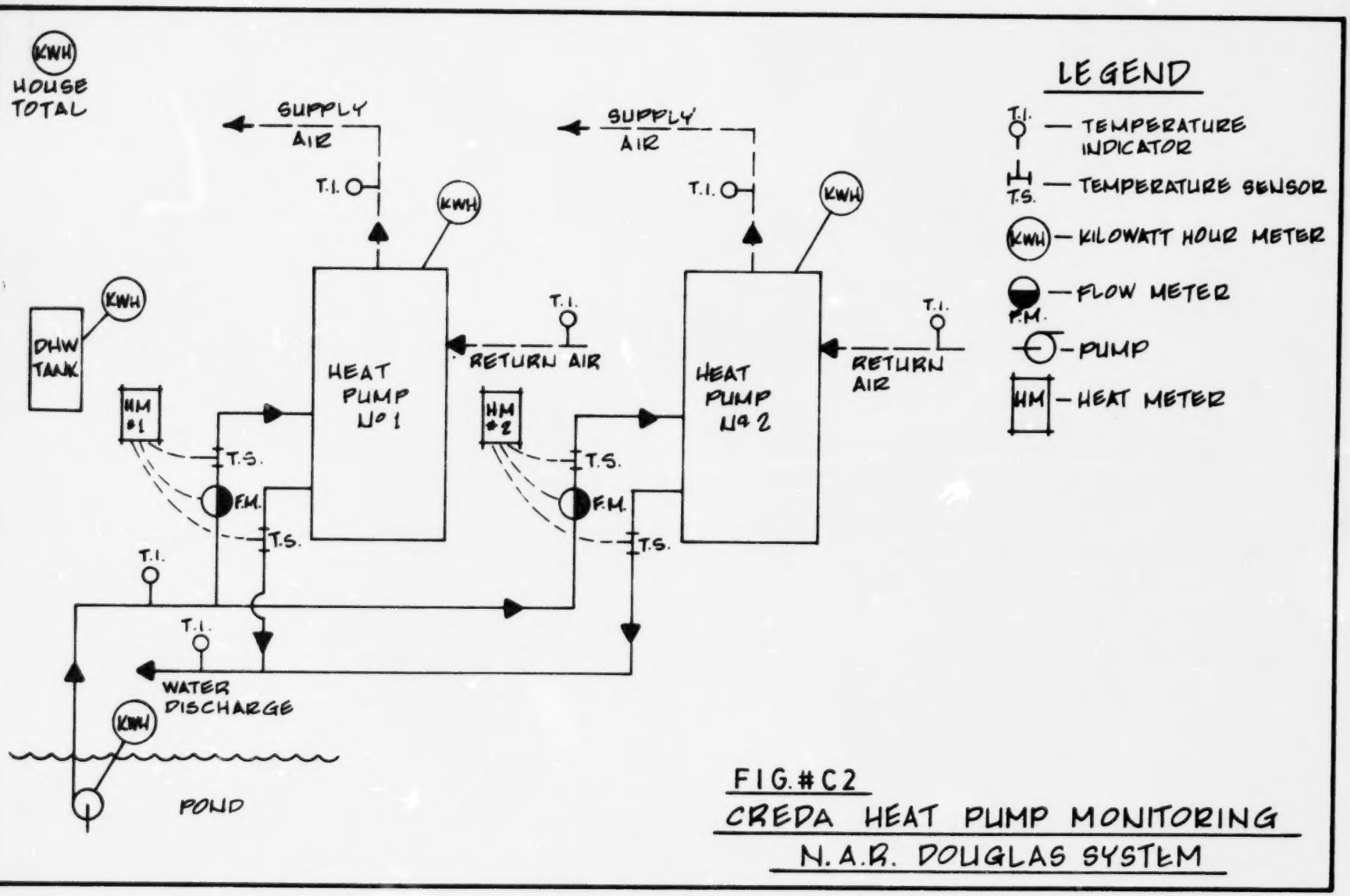


FIG. #C2

CREDA HEAT PUMP MONITORING

N.A.B. DOUGLAS SYSTEM

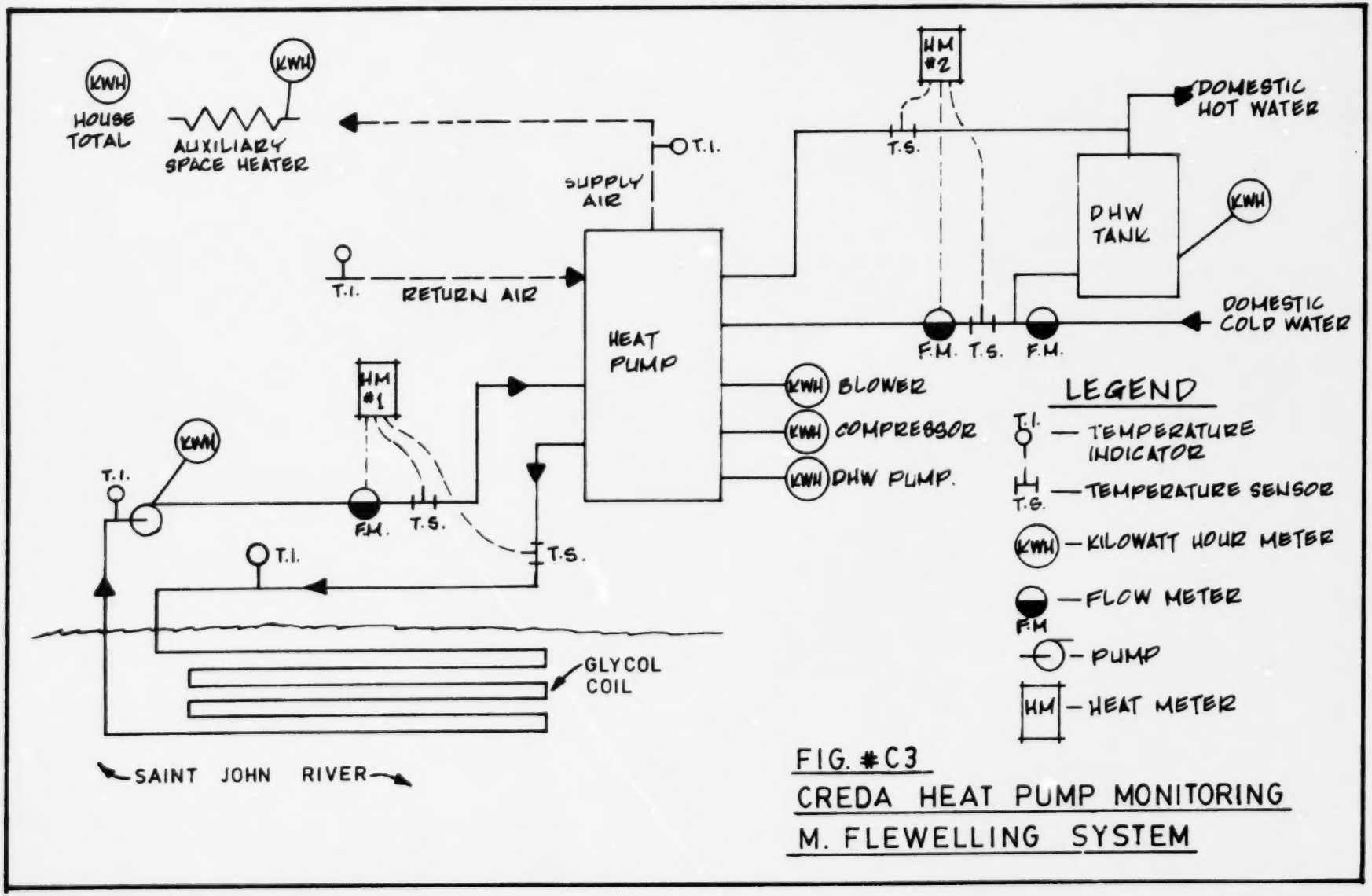


FIG. #C3

CREDA HEAT PUMP MONITORING

M. FLEWELLING SYSTEM

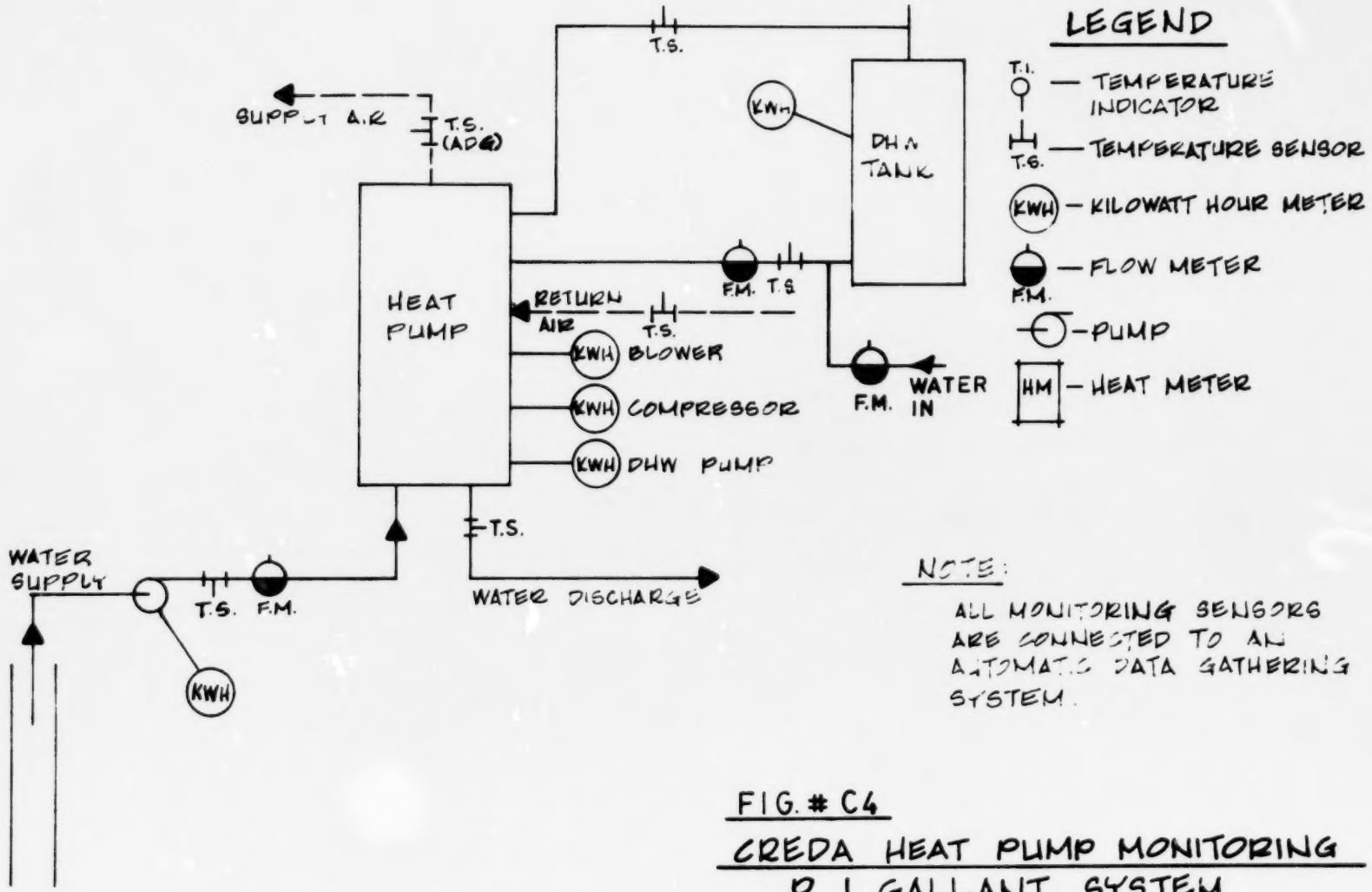


FIG. # C4

CREDA HEAT PUMP MONITORING

R. J. GALLANT SYSTEM

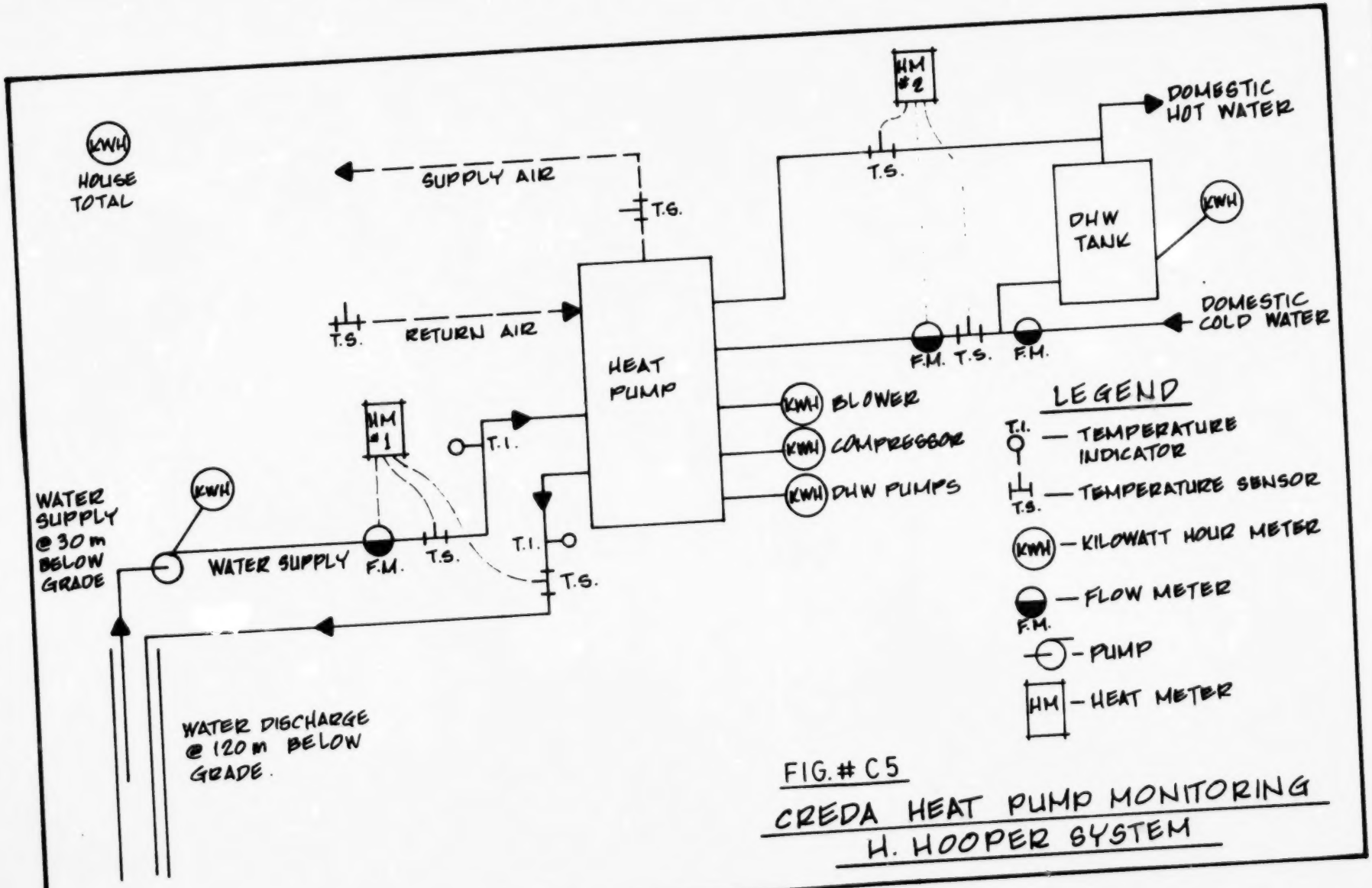


FIG. # C5

CREDA HEAT PUMP MONITORING

H. HOOPER SYSTEM

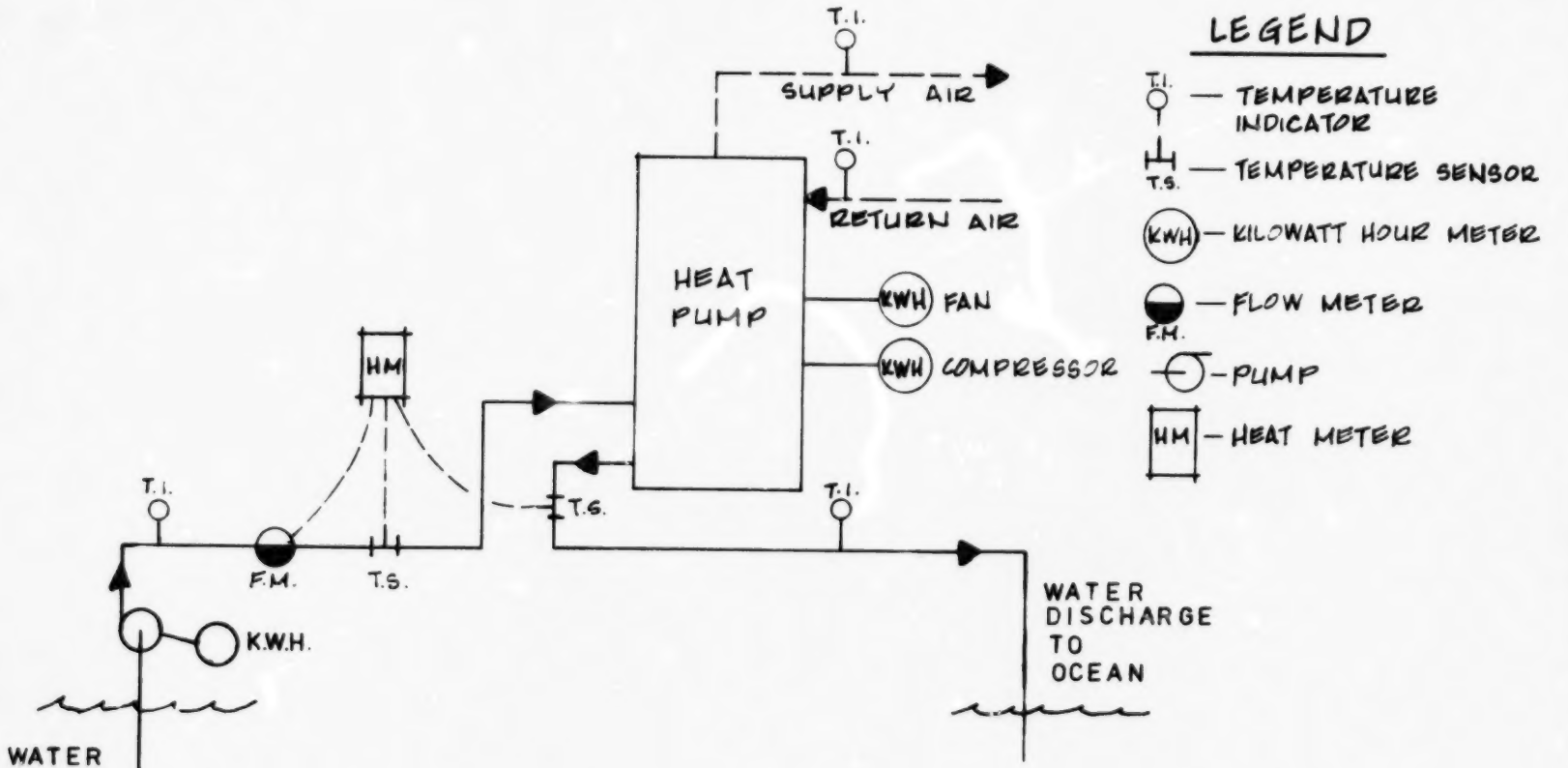


FIG. # C6

CREDA HEAT PUMP MONITORING

LITTLE ROCK FISHERIES SYSTEM

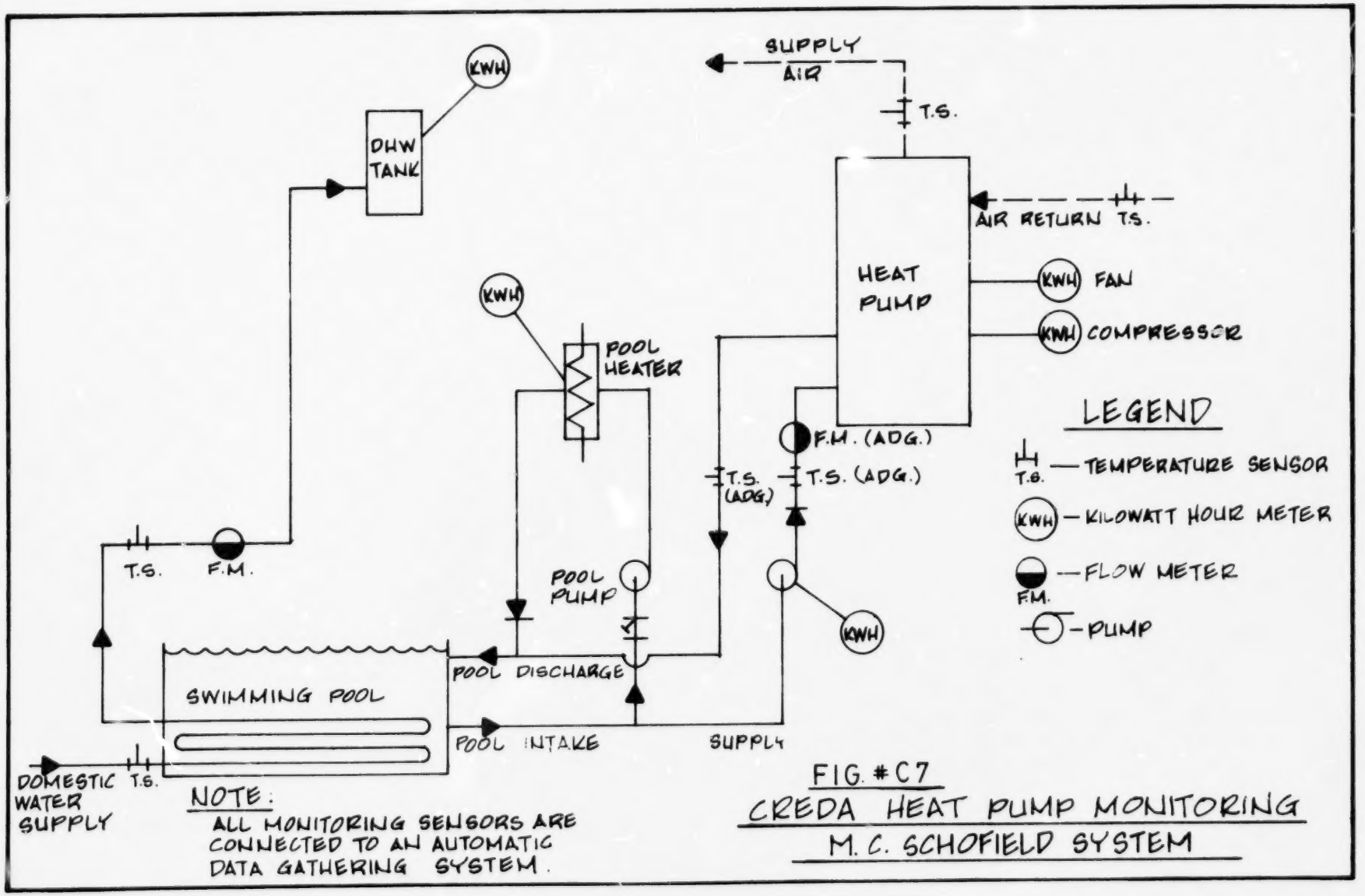
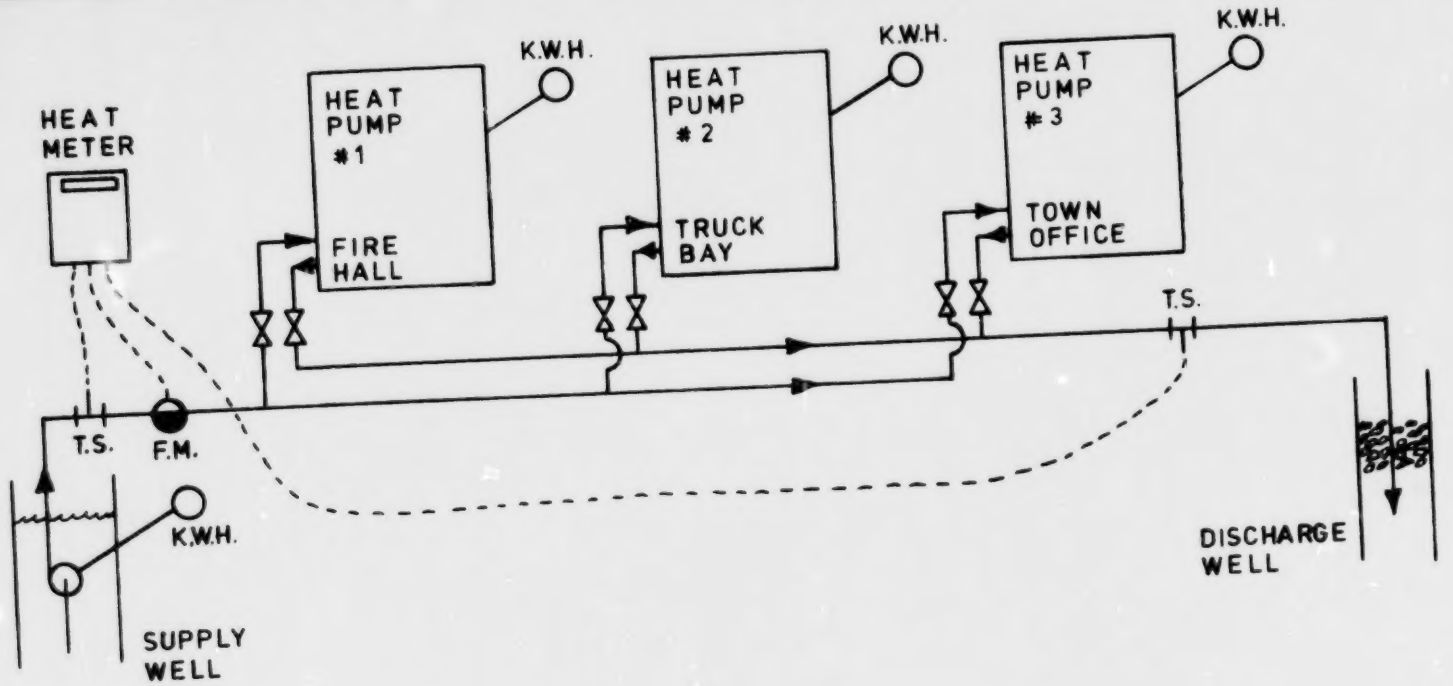


FIG. # C7

CREDA HEAT PUMP MONITORING

M. C. SCHOFIELD SYSTEM



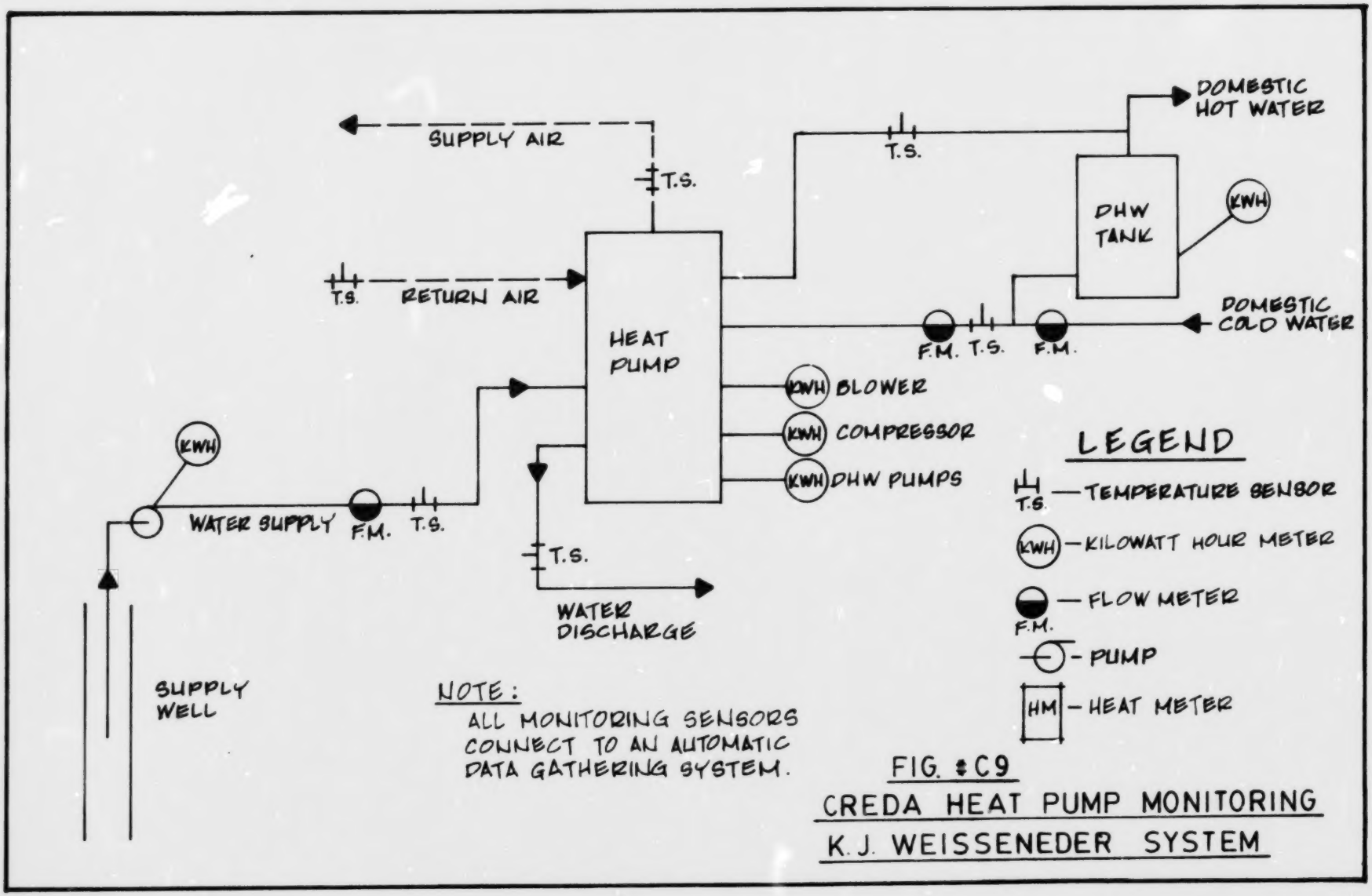
LEGEND:

- T.S. = TEMPERATURE SENSER
- F.M. = FLOW METER
- = PUMP
- K.W.H. = KILOWATT HOURS METER
- = GATE VALVE

FIG. # C8

CREDA HEAT PUMP MONITORING

TIDEHEAD MUNICIPAL BUILDING



NOTE:
ALL MONITORING SENSORS CONNECT TO AN AUTOMATIC DATA GATHERING SYSTEM.

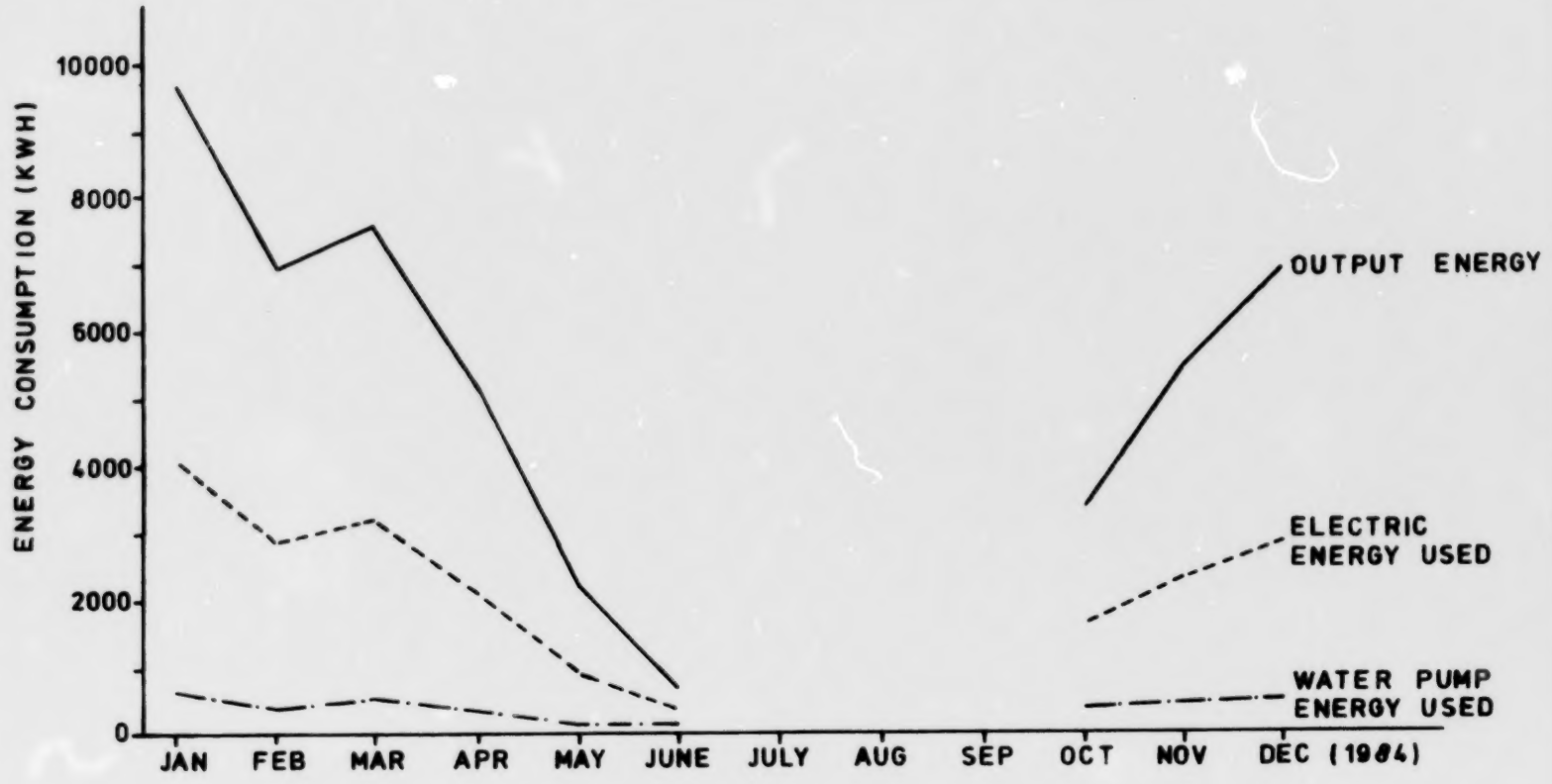
FIG. #C9
CREDA HEAT PUMP MONITORING
K.J. WEISSENEDER SYSTEM

WATER SOURCE HEAT PUMP MONITORING

IN

NEW BRUNSWICK

APPENDIX D - INDIVIDUAL ENERGY CONSUMPTION GRAPHS

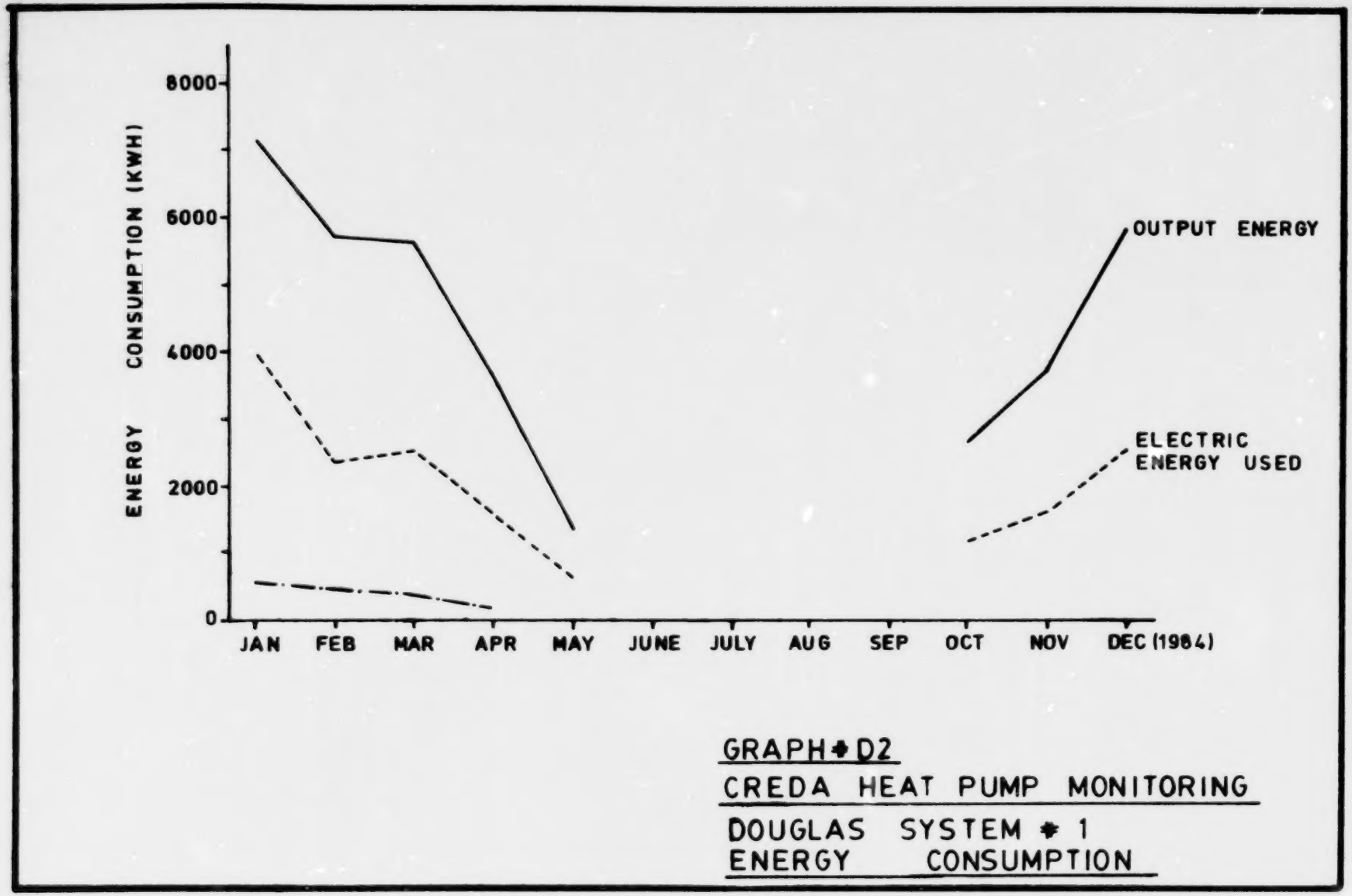


GRAPH#D1

CREDA HEAT PUMP MONITORING

DESCHENES

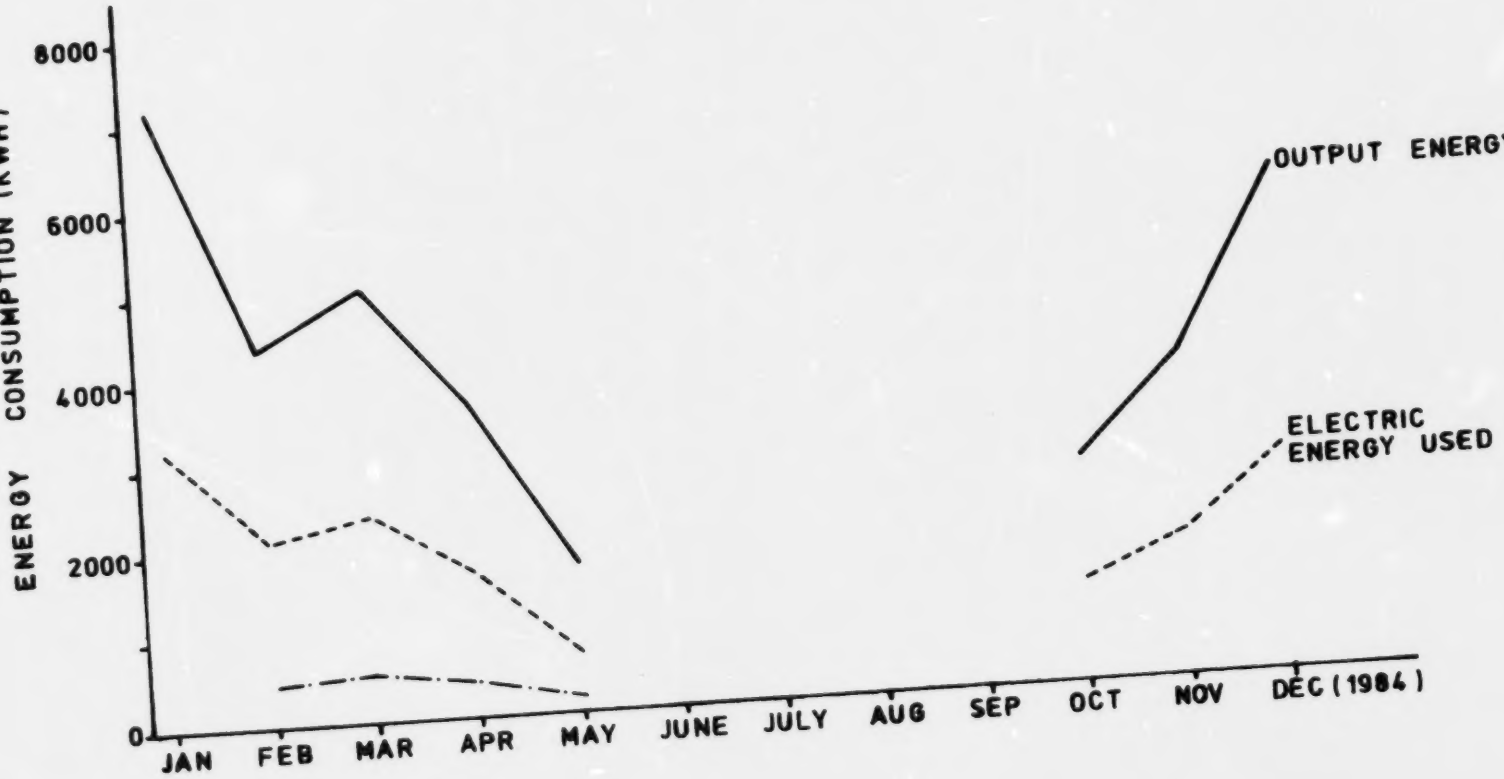
ENERGY CONSUMPTION



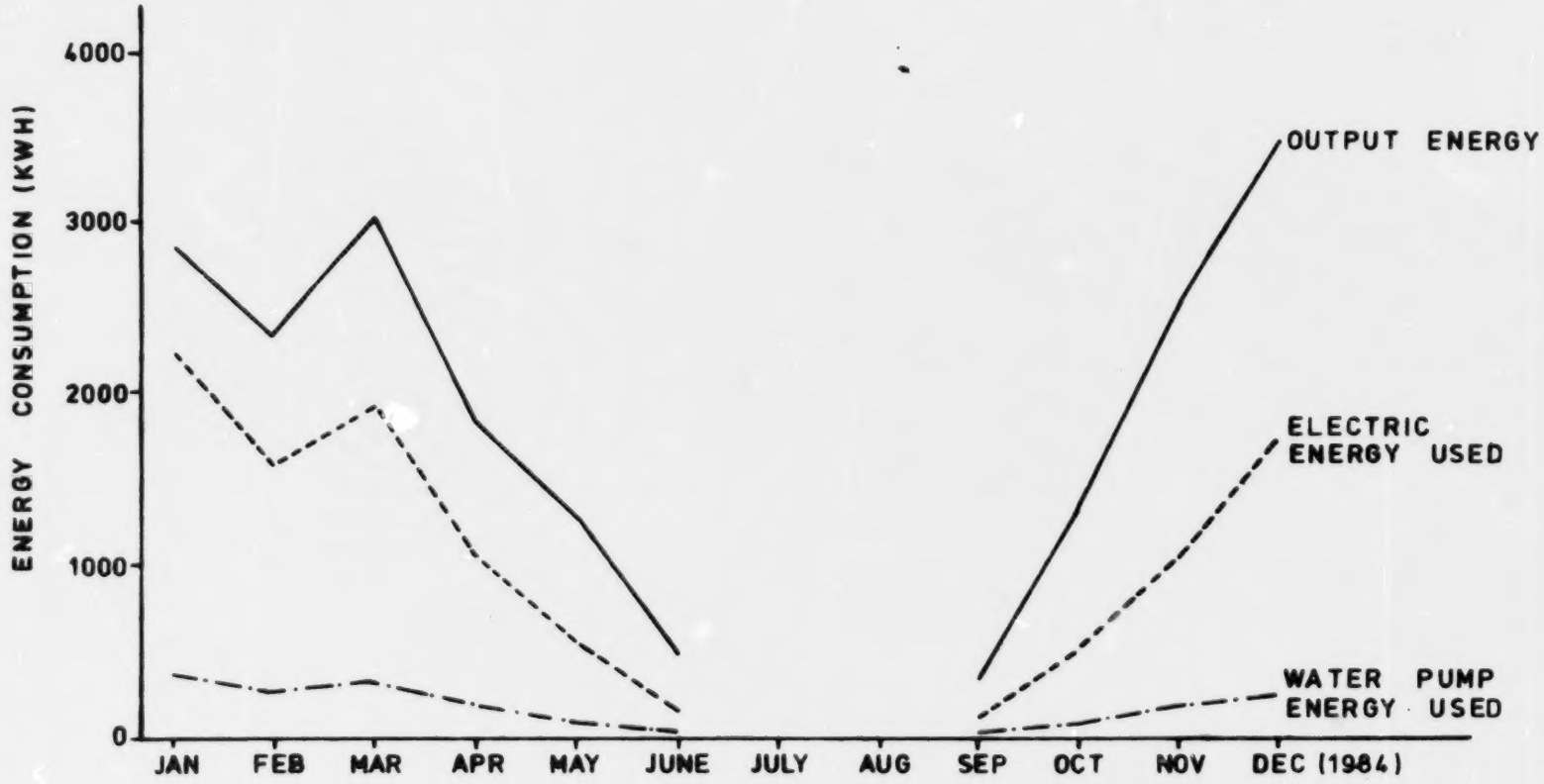
GRAPH # D2

CREDA HEAT PUMP MONITORING

DOUGLAS SYSTEM # 1
ENERGY CONSUMPTION



GRAPH# D3
CREDA HEAT PUMP MONITORING
DOUGLAS SYSTEM # 2
ENERGY CONSUMPTION

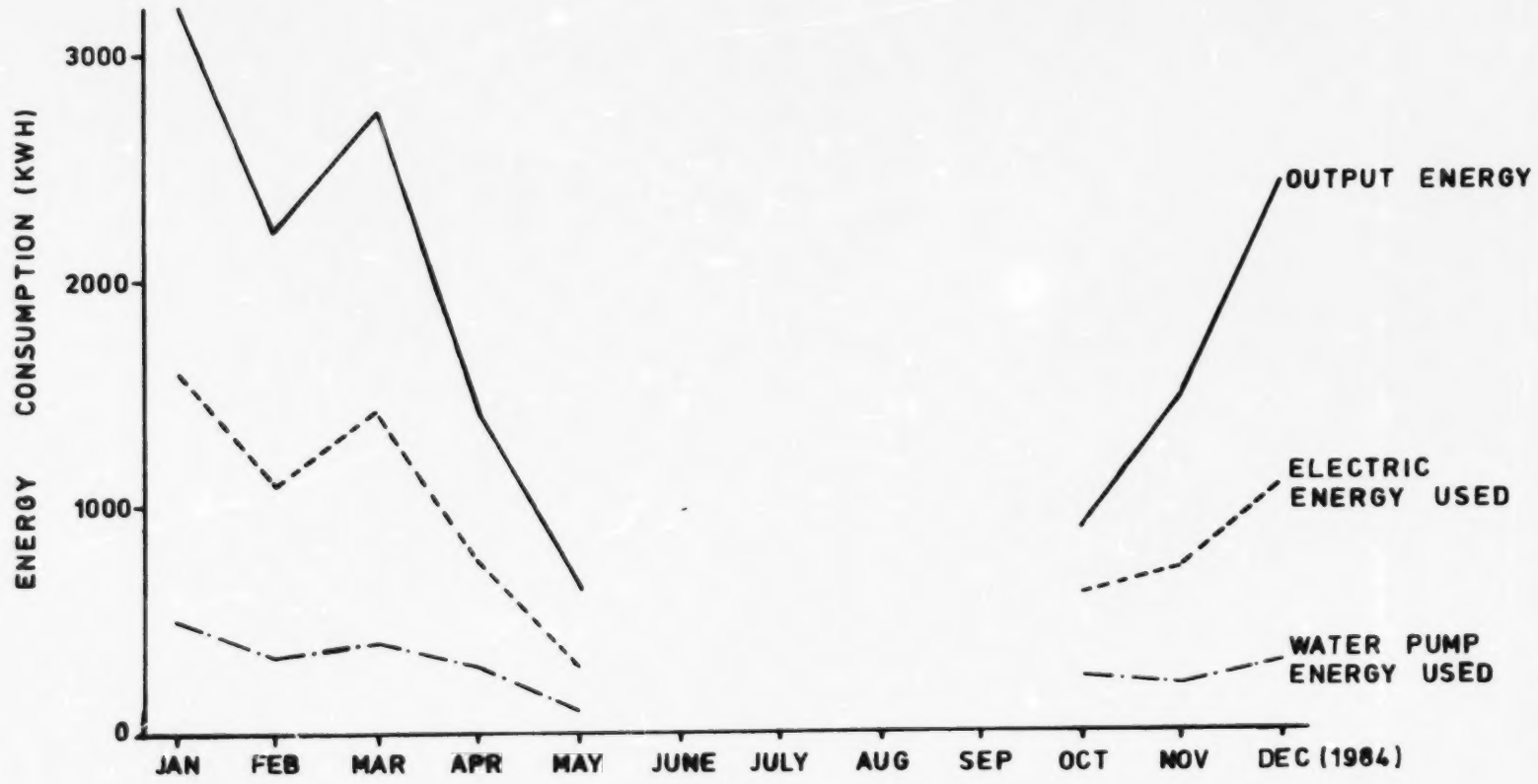


GRAPH # D4

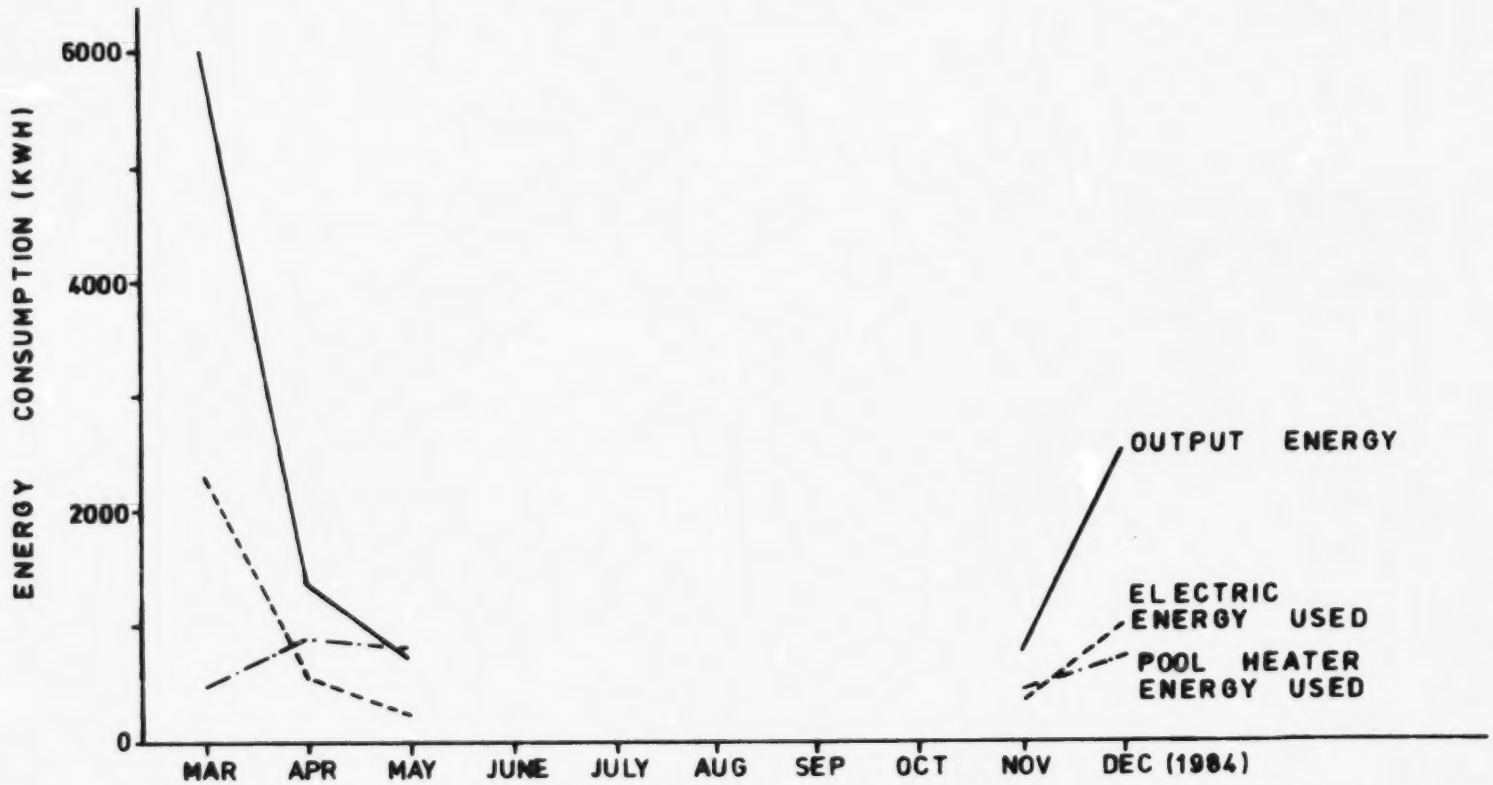
CREDA HEAT PUMP MONITORING

FLEWELLING

ENERGY CONSUMPTION



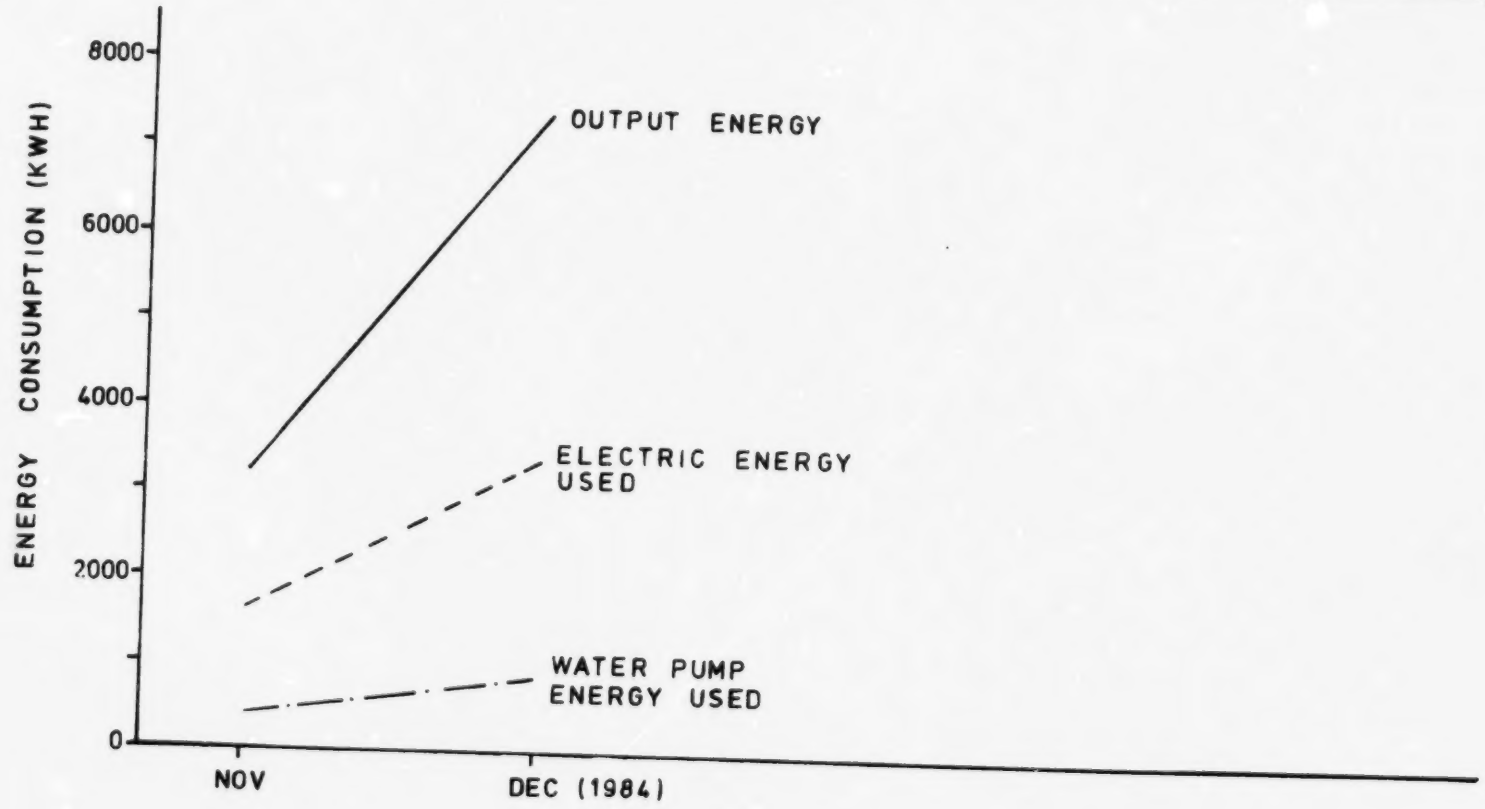
GRAPH#D5
CREDA HEAT PUMP MONITORING
GALLANT ENERGY CONSUMPTION



GRAPH*D6

CREDA HEAT PUMP MONITORING

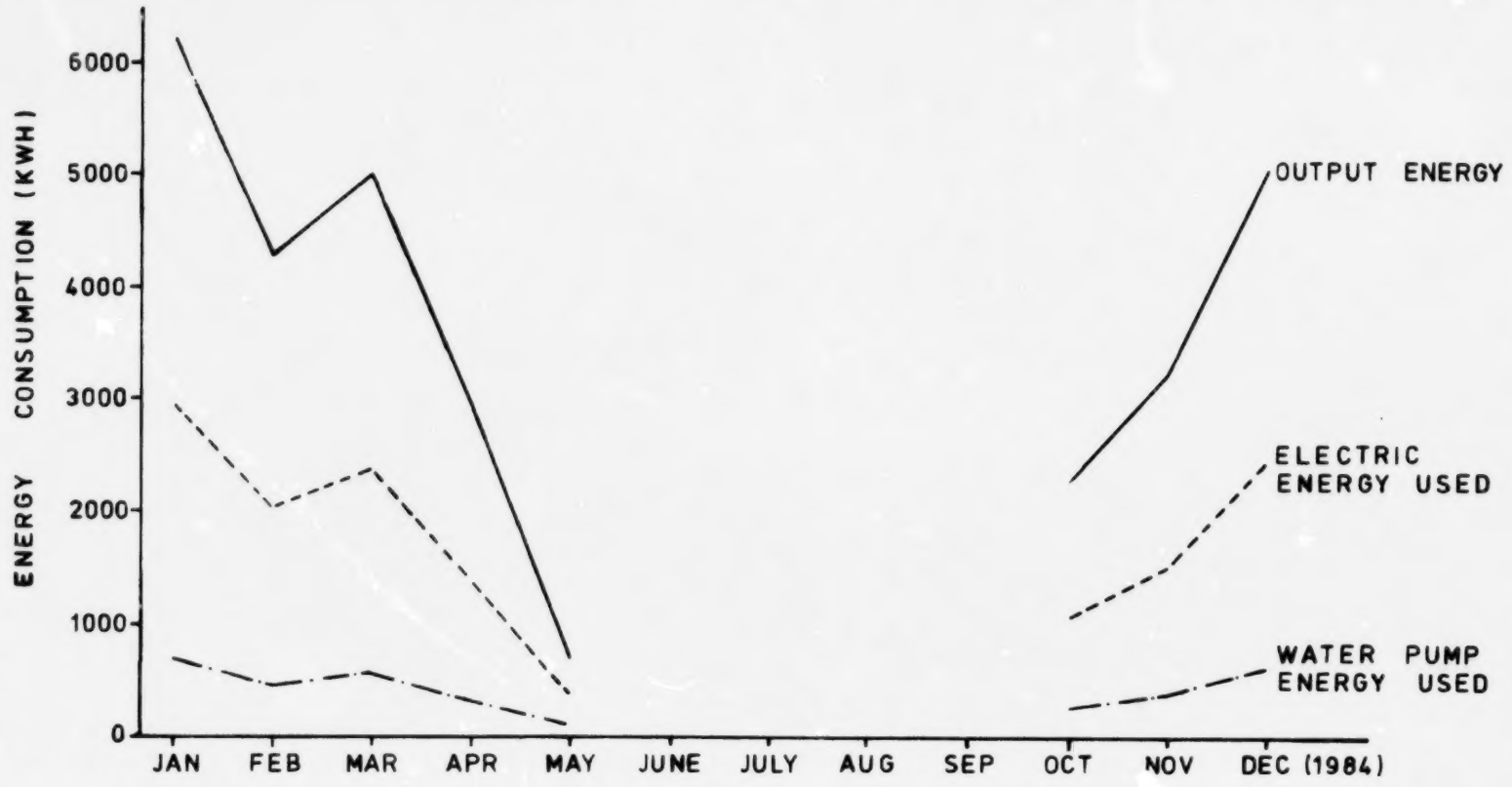
SCHOFIELD ENERGY CONSUMPTION



GRAPH # D7

CREDA HEAT PUMP MONITORING

TIDEHEAD ENERGY CONSUMPTION



GRAPH# D8

CREDA HEAT PUMP MONITORING

WEISSENEDER

ENERGY CONSUMPTION

WATER SOURCE HEAT PUMP MONITORING

IN

NEW BRUNSWICK

APPENDIX E - EQUATIONS USED IN CALCULATIONS

EQUATIONS FOR CREDA HEAT PUMP OUTPUT

1. Total Heating by Heat Pump = DHW Circ + Fan + Compressor + Energy from heat source

2. Electric to Heat Pump = (1) Total Heating by Heat Pump + Supply Pump - Energy from heat source

3. Auxilary Space Heating = Measured Value

4. Additional Bldg. use = Bldg. Total Use - (Electric to Heat Pump(2) + Auxiliary (Electric) Space Heat(3))

5. Heat Pump Space Heating = Total Heating by Heat Pump(1) - Energy to Domestic Water Heating by Heat Pump(11)

6. Unit Consumption without Heat Pump = (H. P. Space Heating(5) + Aux.(3)) / Floor Area *Degree Days

7. Unit Consumption with Heat Pump = (H. P. Space Heating(5)/ COP for Space Heating(20)) / Floor Area* D. D. + Aux. (3)

8. Performance Factor = Total Heating by Heat Pump (1) / Electric to Heat Pump (2)

9. Coefficient of Performance = Total Heating by Heat Pump (1) / (Electric to Heat Pump (2) - Electric to Supply Pump)

EQUATIONS FOR CREDA HEAT PUMP OUTPUT - CONT'D

10. Total DHW Heating Energy = DHW Circ.Pump + DHW Tank + Heat Transfer through DHW Condenser (Heat Meter)

11. Heat Pump Energy to DHW = DHW Circ. + Heat Transfer through H.P. DHW Condenser

12. Fraction DWH by Heat Pump = Heat Pump Energy to DHW (11) / Total DHW Heating Energy (10)

13. Coefficient of Performance for DHW = Total DHW Heating Energy / DHW Circ. + H. P. Energy to DHW(11)/Total H. P. Energy * Compressor Energy

14. DHW Use = DHW Supply (measured)

15. Unit Consumption = DHW Consumption (14) / Total DWH Energy (10)

16. Space Heating Energy Savings - $\overset{(5)}{\text{Energy to Space Heating}} - \overset{(5)}{\text{Energy Space Heating}} / \overset{(20)}{\text{COP for Space Heating}}$

17. DHW Energy Savings = $\overset{(11)}{\text{Energy to DHW by H.P.}} - \overset{(11)}{\text{Energy to DHW by H.P.}} / \overset{(13)}{\text{COP for DWH Heat Pump}}$

EQUATIONS FOR CREDA HEAT PUMP OUTPUT - CONT'D

18. Cost Savings in Space Heating = Cost for Space Heating without H.P. (21) - Cost for Space Heating with H.P. (22)

19. Cost Savings in DHW = Cost for Domestic Water Heating without H.P. (23) - Cost for DWH with H.P. (24)

20. COP (Space hgt.) = Energy to Space Heating (5) / Total Electric Energy Used by System (2) - Energy to DWH by H.P. (11) / Total H.P. heat (1) * Compressor Energy

21. Cost for Space Heating without H.P. = Energy to Space Heating by H.P. (5) * Cost/Unit

22. Cost for Space Heating with H.P. = Energy to Space Heat by H.P. (5) / COP for Space Heating * Cost/Unit

23. Cost for DW Heating without H.P. = Total Domestic Water Heating Energy by H.P. (11) * Cost/Unit

24. Cost for DW Heating with H.P. = Total DWH Energy by H.P. (11) / COP for H.P. (13) * Cost/Unit

WATER SOURCE HEAT PUMP MONITORING PROGRAM

IN

NEW BRUNSWICK

APPENDIX F - TYPICAL COMPUTER PRINTOUT DATA

CREDA HEAT PUMP MONITORING PROGRAM 02-22-1985

GALLANT

INPUT DATA PRINTOUT, (DAILY)

DATE	TEMPERATURES					DEGREE-DAYS	WIND VELOCITY
	WATER IN	WATER OUT	AIR IN	AIR OUT	AMBIENT AIR	SPACE HEAT (deg. C-dys)	(KM/HR)
DEC 1	9.0	6.5	18.6	23.3	2.0	16.0	6.8
DEC 2	10.6	8.8	17.6	21.3	-0.1	18.1	12.3
DEC 3	9.2	6.4	19.4	27.3	-2.7	20.7	8.9
DEC 4	9.2	6.3	19.5	27.9	-0.9	18.9	19.3
DEC 5	9.1	6.0	19.5	29.2	-8.8	26.8	17.5
DEC 6	9.1	6.2	19.4	27.9	-6.3	24.3	12.9
DEC 7	9.2	6.0	19.1	30.1	-9.9	27.9	22.8
DEC 8	9.1	6.2	20.4	29.9	-12.9	30.9	4.0
DEC 9	9.1	6.0	20.0	30.6	-6.3	24.3	5.8
DEC 10	9.1	6.5	19.9	27.8	-5.5	23.6	6.0
DEC 11	9.2	6.3	19.9	27.8	1.2	16.8	7.3
DEC 12	9.3	6.6	19.6	26.2	0.8	17.2	5.5
DEC 13	9.2	6.4	19.8	27.0	3.2	14.8	5.6
DEC 14	9.1	5.9	18.7	28.3	-5.5	23.5	23.5
DEC 15	9.1	6.1	18.6	26.8	-10.2	28.2	8.2
DEC 16	9.8	7.4	18.6	24.2	-3.2	21.2	9.1
DEC 17	9.6	6.7	18.6	25.2	5.7	12.3	21.8
DEC 18	9.1	6.1	19.2	27.3	-0.4	18.6	11.0
DEC 19	9.0	6.0	19.3	28.0	-4.7	22.7	6.3
DEC 20	8.9	5.8	19.4	28.9	2.8	20.8	10.2
DEC 21	9.0	5.8	18.9	29.2	-11.1	29.1	16.9
DEC 22	9.0	6.2	19.4	28.4	-7.4	25.4	11.7
DEC 23	9.1	6.3	19.7	27.3	-4.0	22.0	15.3
DEC 24	9.9	7.3	19.1	25.3	-1.3	19.3	13.5
DEC 25	10.2	7.8	18.4	24.3	-3.1	21.1	22.3
DEC 26	8.9	5.7	18.8	28.9	-14.2	32.2	24.2
DEC 27	8.9	5.4	18.2	30.8	-13.7	37.7	14.6
DEC 28	8.9	5.6	19.4	29.7	-10.8	28.8	4.1
DEC 29	9.2	6.8	18.0	24.1	-4.6	22.6	2.1
DEC 30	8.9	5.7	18.9	28.6	-7.2	25.2	16.8
DEC 31	8.9	5.6	18.5	29.8	-15.9	33.8	1.4
VALUE	AVE.	AVE.	AVE.	AVE.	AVE.	TOTAL	AVE.
	9.2	6.3	19.1	27.5	-5.4	724.7	11.9

CREDA HEAT PUMP MONITORING PROGRAM 02-22-1985

GALLANT

INPUT DATA PRINTOUT. (DAILY)

DATE	CONSUMPTION - ELECTRIC, (KWH'S)							HEAT PUMP HEAT METERS (BTU'S x 1000)		DHW FLOW (liters)
	DHW TANK	DHW PUMP	FAN	COMP	SUPPLY PUMP	HOUSE	AUXILIARY	PRIMARY	DHW	
DEC 1	21	0	1	10	6	N/D	N/D	N/A	N/A	329
DEC 2	15	1	1	9	11	N/D	N/D	N/A	N/A	260
DEC 3	6	1	3	18	9	N/D	N/D	N/A	N/A	154
DEC 4	2	1	3	21	10	N/D	N/D	N/A	N/A	52
DEC 5	11	2	4	33	13	N/D	N/D	N/A	N/A	280
DEC 6	9	1	3	19	10	N/D	N/D	N/A	N/A	246
DEC 7	3	1	3	19	9	N/D	N/D	N/A	N/A	122
DEC 8	15	2	3	24	12	N/D	N/D	N/A	N/A	351
DEC 9	3	1	4	29	14	N/D	N/D	N/A	N/A	128
DEC 10	13	1	3	18	10	N/D	N/D	N/A	N/A	329
DEC 11	10	1	3	19	10	N/D	N/D	N/A	N/A	238
DEC 12	12	1	2	15	8	N/D	N/D	N/A	N/A	244
DEC 13	4	1	3	17	9	N/D	N/D	N/A	N/A	103
DEC 14	6	1	4	27	13	N/D	N/D	N/A	N/A	191
DEC 15	24	1	3	23	11	N/D	N/D	N/A	N/A	519
DEC 16	4	1	2	13	7	N/D	N/D	N/A	N/A	88
DEC 17	9	1	2	17	9	N/D	N/D	N/A	N/A	208
DEC 18	7	1	3	26	10	N/D	N/D	N/A	N/A	190
DEC 19	4	1	3	22	11	N/D	N/D	N/A	N/A	151
DEC 20	8	1	4	28	12	N/D	N/D	N/A	N/A	179
DEC 21	3	1	2	15	8	N/D	N/D	N/A	N/A	96
DEC 22	4	0	2	13	7	N/D	N/D	N/A	N/A	109
DEC 23	17	1	3	20	10	N/D	N/D	N/A	N/A	414
DEC 24	22	1	2	16	9	N/D	N/D	N/A	N/A	458
DEC 25	12	1	2	20	9	N/D	N/D	N/A	N/A	198
DEC 26	9	1	4	27	12	N/D	N/D	N/A	N/A	277
DEC 27	4	2	6	46	19	N/D	N/D	N/A	N/A	227
DEC 28	7	1	4	32	16	N/D	N/D	N/A	N/A	267
DEC 29	19	1	2	14	8	N/D	N/D	N/A	N/A	397
DEC 30	8	1	3	21	12	N/D	N/D	N/A	N/A	222
DEC 31	0	1	5	32	15	N/D	N/D	N/A	N/A	1
VALUE	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL					TOTAL
	290	29	93	662	307					7025

CREDA HEAT PUMP MONITORING PROGRAM 02-24-1985

GALLANT

GENERAL & SPACE HEATING RESULTS, (DAILY)

DATE	ENERGY (KWH'S)					SPACE HEATING UNIT CONSUMPTION (KWH/DD@2)		PERFORMANCE FACTOR	COEFFICIENT OF PERFORMANCE
	TOTAL HEAT PUMP	ELECTRIC TO HT PUMP	AUXILIARY SP. HTG.	ADDITIONAL BLDG. USE	HT. PUMP SP. HTG.	W HT PUMP	W/O HT PUMP		
DEC 1	35.2	17.6	12.7	0.0	27.7	0.0125	0.0180	2.06	2.97
DEC 2	27.7	22.9	12.4	0.0	20.3	0.0136	0.0129	1.21	2.41
DEC 3	68.1	30.4	6.4	0.0	50.1	0.0111	0.0195	2.24	3.21
DEC 4	71.2	34.2	6.6	0.0	50.3	0.0131	0.0215	2.08	2.92
DEC 5	104.3	51.2	6.7	0.0	76.2	0.0131	0.0221	2.04	2.72
DEC 6	83.6	33.7	0.8	0.0	63.0	0.0088	0.0198	2.48	3.50
DEC 7	69.6	30.6	0.1	0.0	48.9	0.0066	0.0128	2.24	3.13
DEC 8	87.4	41.7	9.3	0.0	63.6	0.0082	0.0148	2.10	2.97
DEC 9	113.6	48.6	12.8	0.0	84.2	0.0158	0.0285	2.34	3.29
DEC 10	73.4	31.7	0.3	0.0	56.5	0.0084	0.0172	2.32	3.34
DEC 11	77.4	32.9	12.9	0.0	58.1	0.0174	0.0302	2.36	3.38
DEC 12	57.5	25.6	7.0	0.0	44.3	0.0121	0.0213	2.25	3.27
DEC 13	63.7	29.4	6.6	0.0	47.1	0.0152	0.0259	2.17	3.10
DEC 14	102.8	45.3	6.6	0.0	74.1	0.0135	0.0245	2.27	3.21
DEC 15	82.3	38.1	6.9	0.0	58.8	0.0098	0.0166	2.16	3.10
DEC 16	44.5	21.8	19.0	0.0	34.5	0.0128	0.0150	2.04	2.94
DEC 17	64.3	28.3	6.6	0.0	47.7	0.0176	0.0315	2.28	3.27
DEC 18	80.1	40.4	12.6	0.0	54.7	0.0172	0.0258	1.98	2.64
DEC 19	83.8	37.1	7.1	0.0	64.1	0.0119	0.0212	2.26	3.21
DEC 20	95.9	43.2	18.2	0.0	68.7	0.0136	0.0298	2.22	3.14
DEC 21	57.4	25.7	3.6	0.0	41.5	0.0061	0.0111	2.24	3.17
DEC 22	54.1	22.3	5.7	0.0	40.9	0.0072	0.0134	2.43	3.44
DEC 23	83.7	33.6	13.1	0.0	64.5	0.0137	0.0252	2.49	3.57
DEC 24	50.8	27.3	6.7	0.0	39.4	0.0113	0.0171	1.86	2.79
DEC 25	57.9	30.1	6.7	0.0	47.7	0.0111	0.0191	1.92	2.56
DEC 26	106.0	45.5	18.5	0.0	76.2	0.0134	0.0214	2.33	3.31
DEC 27	176.5	72.7	31.1	0.0	139.6	0.0176	0.0267	2.43	3.24
DEC 28	122.1	53.2	0.6	0.0	89.1	0.0112	0.0222	2.30	3.27
DEC 29	48.7	25.0	0.0	0.0	37.5	0.0069	0.0119	1.95	2.81
DEC 30	77.1	37.5	0.0	0.0	57.1	0.0089	0.0151	2.06	2.83
DEC 31	119.1	53.8	0.0	0.0	84.2	0.0094	0.0178	2.22	3.08
VALUE	TOTAL 2438.9	TOTAL 1111.3	TOTAL 229.1	TOTAL 3.0	TOTAL 1795.4	AVE. 0.0119	AVE. 0.0204	AVE. 2.17	AVE. 3.093

CREDA HEAT PUMP MONITORING PROGRAM 02-22-1985

GALLANT

DOMESTIC WATER HEATING RESULTS, (DAILY)

DATE	ENERGY (KWH'S) TOTAL HEATING	HT PUMP ENERGY	FRACTION BY HT PUMP	COEFFICIENT OF PERFORMANCE	DHW USE (L)	UNIT CONSUMPTION (L/KWH)
DEC 1	28.7	7.5	0.26	1.21	329	11.492
DEC 2	22.1	7.3	0.33	1.21	260	11.775
DEC 3	24.1	18.0	0.75	2.09	154	6.390
DEC 4	23.3	20.9	0.90	2.52	52	2.226
DEC 5	38.7	28.0	0.72	1.82	280	7.236
DEC 6	29.7	20.6	0.69	1.95	246	8.261
DEC 7	21.6	18.7	0.86	2.48	122	5.655
DEC 8	38.6	23.8	0.62	1.68	351	9.097
DEC 9	31.9	29.3	0.92	2.85	128	4.024
DEC 10	30.2	16.9	0.56	1.66	329	10.890
DEC 11	29.6	19.3	0.67	1.96	238	8.200
DEC 12	24.9	13.2	0.53	1.59	244	9.803
DEC 13	20.8	16.7	0.80	2.23	103	4.944
DEC 14	34.7	28.8	0.83	2.38	191	5.501
DEC 15	47.9	23.5	0.49	1.51	519	10.827
DEC 16	14.7	10.0	0.70	1.86	88	6.178
DEC 17	26.1	16.9	0.64	1.81	209	7.976
DEC 18	32.4	25.4	0.78	1.94	190	5.870
DEC 19	27.7	23.6	0.85	2.46	151	5.421
DEC 20	35.2	27.2	0.77	2.15	179	5.091
DEC 21	18.8	16.9	0.85	2.44	96	5.109
DEC 22	17.6	12.2	0.78	2.05	109	6.207
DEC 23	36.2	19.2	0.53	1.62	414	11.410
DEC 24	33.5	11.4	0.34	1.29	458	13.671
DEC 25	22.1	10.2	0.46	1.40	198	8.956
DEC 26	36.4	27.9	0.76	2.17	277	7.593
DEC 27	51.2	46.8	0.92	3.74	228	4.453
DEC 28	33.6	32.3	0.97	2.30	247	6.693
DEC 29	29.7	11.1	0.38	1.29	393	13.256
DEC 30	31.6	24.0	0.76	2.05	222	7.030
DEC 31	25.7	24.8	0.99	2.10	1	0.039
VALUE	TOTAL 974.0	TOTAL 647.5	AVE. 0.66	AVE. 2.01	TOTAL 7655	AVE. 7.863

CPEEA HEAT PUMP MONITORING PROGRAM 02-22-1985

GALLANT

ENERGY AND COST SAVINGS, (DAILY)

DATE	ENERGY SAVINGS (KWH)		COST SAVINGS ($)	
	SPACE HEATING	DOMESTIC WATER HEATING	SPACE HEATING	DOMESTIC WATER HEATING
DEC 1	12.3	1.3	0.49	0.05
DEC 2	-0.0	1.3	-0.00	0.05
DEC 3	24.4	9.4	0.98	0.38
DEC 4	22.1	12.6	0.88	0.50
DEC 5	33.9	12.6	1.36	0.50
DEC 6	34.0	10.0	1.36	0.40
DEC 7	24.3	11.2	0.97	0.45
DEC 8	28.6	7.6	1.14	0.28
DEC 9	43.2	19.0	1.73	0.76
DEC 10	29.0	6.7	1.16	0.27
DEC 11	30.1	9.2	1.20	0.37
DEC 12	22.2	4.9	0.89	0.20
DEC 13	22.3	9.2	0.89	0.37
DEC 14	36.4	16.7	1.45	0.67
DEC 15	27.2	7.9	1.09	0.32
DEC 16	15.5	4.6	0.62	0.19
DEC 17	23.7	7.4	0.95	0.30
DEC 18	22.5	12.3	0.90	0.49
DEC 19	29.3	14.0	1.17	0.56
DEC 20	3..3	14.3	1.71	0.58
DEC 21	20.1	9.4	0.80	0.38
DEC 22	21.7	7.4	0.86	0.29
DEC 23	35.5	7.3	1.42	0.29
DEC 24	15.6	2.5	0.62	0.10
DEC 25	26.9	3.1	0.07	0.12
DEC 26	24.8	15.0	1.59	0.60
DEC 27	50.0	29.8	2.7[illegible]	1.19
DEC 28	44.4	19.2	1.78	0.77
DEC 29	15.9	2.5	0.63	0.10
DEC 30	22.2	12.3	0.89	0.49
DEC 31	40.6	23.8	1.60	0.94
TOTAL	858.9	327.1	34.36	13.08

POOR
QUALITY
ORIGINAL